Finishing Rules Handbook for Plastics

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ABSTRACT: This handbook summarizes design guidelines from a Manufacturing perspective for the selection of the finish to be used in the design of plastic parts.

APPLICABILITY: This handbook applies to Digital engineers who design or manufacture plastic components.

STATUS: APPROVED 26-NOV-1991; use VTX SMC for current status.

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CHAPTER 1

INTRODUCTION

1.1 PURPOSE

This handbook summarizes design principles, guidelines, and information concerning the finishing of plastic components intended to be used when designing components made of plastic materials. These rules have been created so that engineers and designers can design plastic parts with the manufacturing process in mind. The intent was also to aid in the selection of a finish to achieve design requirements, while maintaining manufacturing goals.

1.2 SCOPE

This handbook applies to features of plastic parts that have an impact on finishing requirements or processes, and it also aids in the selection of a finish to achieve design requirements, and ensures manufacturability. This handbook is not intended to identify all manufacturing issues, but to address the most common, and provide guidance along with some reasoning. It is intended to complement the efforts of producibility and manufacturing engineers in the area of design and manufacturing.

1.3 RESPONSIBILITIES

The Finishing Rules Group is responsible for the content of this handbook. Changes must be approved by this group prior to incorporation into the handbook. Comments and proposed changes should be sent to the owner of the document. The following team created the initial issue of this handbook.

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1.4 STRUCTURE OF DESIGN INFORMATION

General Description

Chapter 1—Introduction

The finish design information contained in this handbook takes the form of rules organized in a hierarchy of features and considerations. The hierarchy used to organize the rules provides a guide for users to locate appropriate information within this handbook. The text of the rules is uniformly formatted, and illustrations are included to aid in interpreting and using each rule.

Chapter 2—Thermoplastics

Chapter 2 covers the uses of thermoplastics. This chapter presents the features that support most engineering requirements for finishing plastics and will support future Artificial Intelligence (AI) tool development, such as, The Design Advisor.

1.5 HANDBOOK HIERARCHY

```
Technology (volume)------------Finishing

Process (book)-----------------Plastics

Material (chapter)-------------Thermoplastics

Feature class (section)--------Cosmetic shielding corrosion
                                protection

Design rule (specific rules)---Paint, plate, and special coatings
```

1.5.1 Rule Format

The finishing rules have been formatted as follows.

```
-----------------------------------------------------------------
SECTION:  Basic process classification to which each rule
          applies (for example, Plastic Finishing)
-----------------------------------------------------------------
FEATURE:  The feature or consideration about which each rule
          provides information (for example,
          Paint - Enamel/Lacquer)
-----------------------------------------------------------------
RULE CATEGORY:  Each rule falls under one of the following
                categories.

PRINCIPLE--Design rules that should not be broken.
GUIDELINE--Design rules that direct the user to the optimum
           solution.
INFORMATION--General knowledge concerning a specific feature.
-----------------------------------------------------------------
RULE:  The limitations, considerations, and other information
       specific to the feature at hand.
-----------------------------------------------------------------
REASONING: The underlying fact or cause that provides the logic
           for the rule.
-----------------------------------------------------------------
ALTERNATIVE: Provides a design choice outside the limits of the
             rule.
-----------------------------------------------------------------
ALTERNATIVE IMPACT: The effect(s) of using the alternative
                    rather than following the prescribed rule.
```

1.5.2 Defining the Rule

The plastic design rules are used to describe how/why design choices are, or should be made. The rules are divided into the following categories.

GUIDELINE	Design rule that directs the user to the **OPTIMUM SOLUTION**
INFORMATION	Provides knowledge derived from study, experience, or standards....**FACTS**

CHAPTER 2

THERMOPLASTICS

2.1 FINISHING PROCESS—FEATURE REQUIREMENTS OVERVIEW

INFORMATION

RULE/S:

1. Feature requirements within the Finishing Process will be divided into the following major categories: (see Figure 2–1.)
   - Cosmetics
   - Shielding
   - Protection
   - Wearability
2. These major categories will be divided into the following major feature types: (See Figure 2–1.)
   - Paint
   - Plating
   - Special coatings

   NOTE: Finishing of plastic material can be an environmental concern subject to regulatory control.

REASON:

These categories and feature types should support most engineering requirements for finishing plastic substrates and will support future Artificial Intelligence (AI) tool development, for example, The Design Advisor.

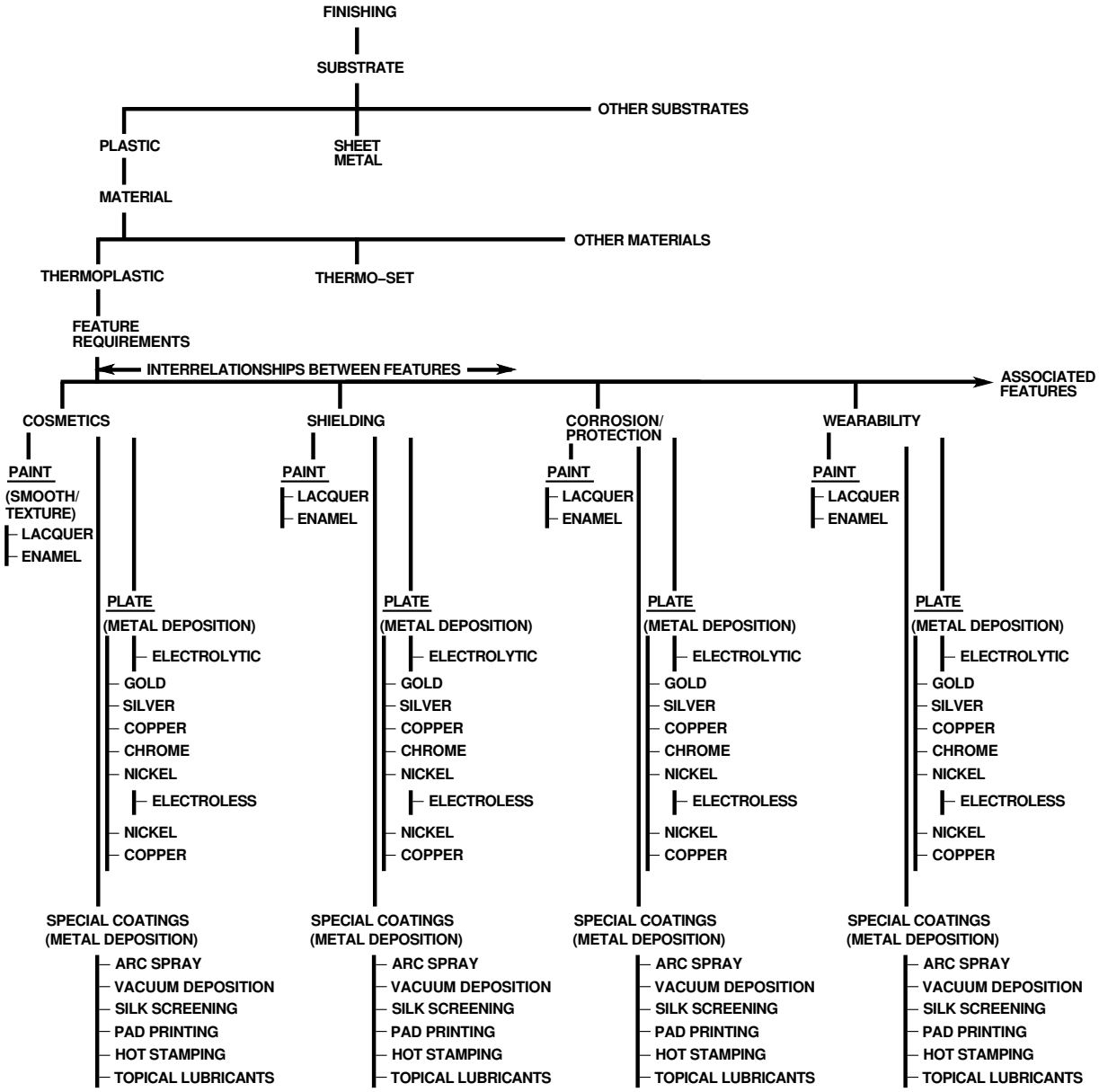
ALTERNATIVE:

Not applicable

ALTERNATIVE IMPACT:

Not applicable

Figure 2–1: Finishing Architecture



2.2 FINISHING - COSMETIC

2.2.1 PAINT/PLATE/SPECIAL COATINGS

INFORMATION

RULE/S:

1. Painting is a finishing option when the following criteria must be met:
   - Precolored plastic material is *not* available
   - Ultraviolet (UV) stability
   - Product uniformity
   - Multicolored part requirement

2. Plating is a finishing option when the following criteria must be met:

   Metal-like appearance

   NOTE: Generally, it is more cost-effective to paint as opposed to plate. However, the most cost-effective approach would be to use UV stable custom colored resins.

3. Special coatings is a finishing option when the following criteria must be met:

   Special surface conditions

REASON/S:

- Painting of plastics is an acceptable standard manufacturing process readily available over a large vendor base.
- Plating of plastics is less available as a manufacturing process and should be used *only* when no other options are acceptable.
- Special coatings are developed to satisfy special surface conditions that cannot be satisfied through the use of standard painting and/or plating materials. See a Producibility Engineer for specific design requirements.

ALTERNATIVE: Mold-in color

ALTERNATIVE IMPACT: It is more cost-effective to use UV stable custom-colored resins, thereby yielding the finished color during the molding process.

2.2.2 PAINT

INFORMATION

RULE:

Features within the paint process are divided into the following categories. The order of recommended use is:

- Enamel
- Lacquer

NOTE: Refer to *DEC STD 092-0 Finish and Color Standard - Introduction and General Requirements* for more specific information.

REASON/S:

- The relative ranking is based upon cost, technical expertise, and available and approved vendor base.
- These feature categories should support most engineering requirements for finishing (painting) plastic substrates, and will support future AI tool development, for example, The Design Advisor.

ALTERNATIVES:

- Plating
- Special coatings
- Molded-in color in base material

ALTERNATIVE IMPACT:

Positive or negative impact of alternatives would have to be evaluated based upon specific design requirements. See a Producibility Engineer.

2.2.3 PAINT—ENAMEL/LACQUER

GUIDELINE

RULE/S:

1. Irregular surface conditions, blind holes, recessed areas, and so on, can lead to processing problems, such as non-uniform coating. See Figure 2–3.
2. The plastic substrate and enamel *must* be compatible. See a Producibility Engineer and DEC STD 092-0 for specific design recommendations.
3. Lacquers are generally used for prototype development and not volume manufacturing.
4. Enamels are *not* effective for hiding base material (substrate) surface irregularities, for instance, structural foam parts.
5. Enamels are recommended for most cosmetic applications.
6. Primer coat(s) may be required to satisfy proper coverage and/or adhesion. See a Producibility Engineer for specific design recommendations.

   NOTE: Transition features should be designed into a multicolored painted part to facilitate ease of color blending. See Figure 2–2.

REASON/S:

- Enamels are solvent based and can lead to dissolving of the base material (substrate), which may have a detrimental effect on the product specifications.
- Enamels and lacquer are applied using a spraying process (not immersion).
- Irregular surface conditions, blind holes, recessed areas, and so on, can result in poor adhesion or non-uniform coating (thickness and coverage). See Figure 2–3.

ALTERNATIVE/S:

- Mold-in color in base material
- Plating
- Special coatings

ALTERNATIVE IMPACT: Positive or negative impact of alternatives would have to be evaluated based upon specific design requirements. See a Producibility Engineer.

Figure 2–2: Transition Features

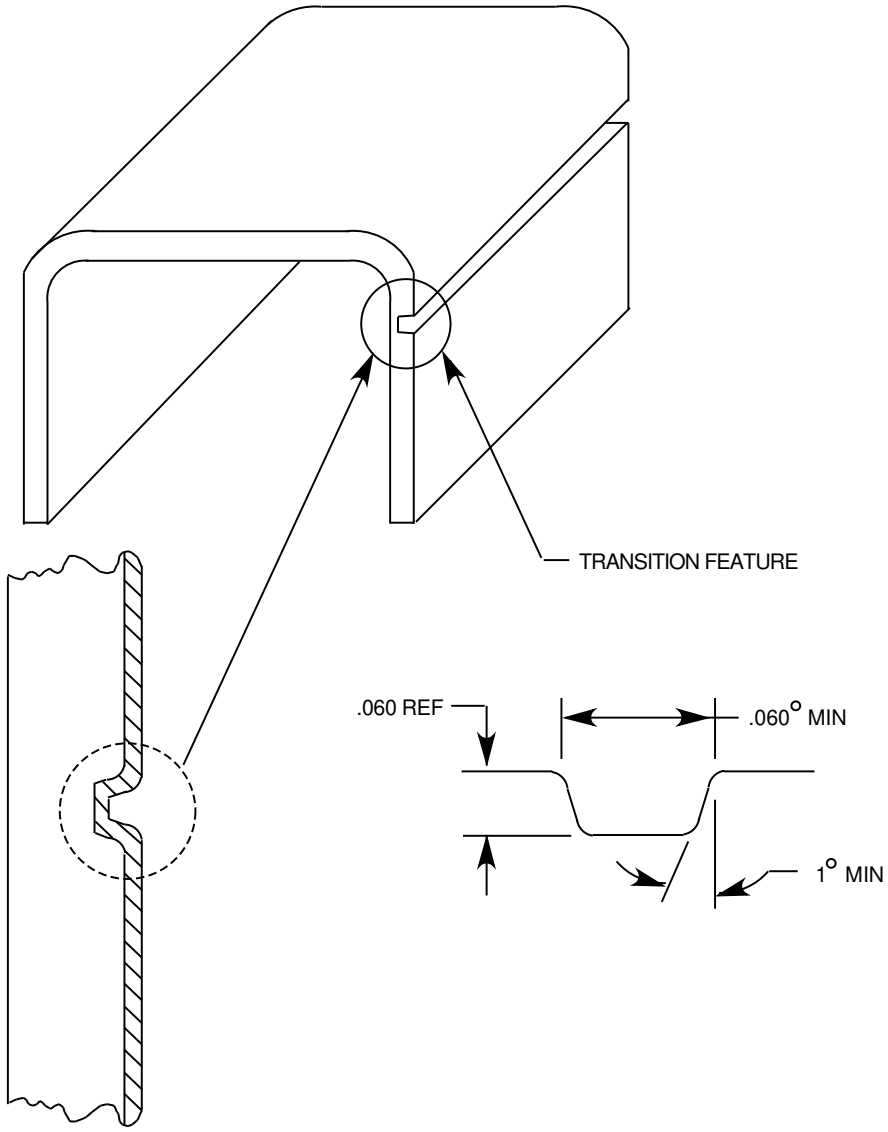
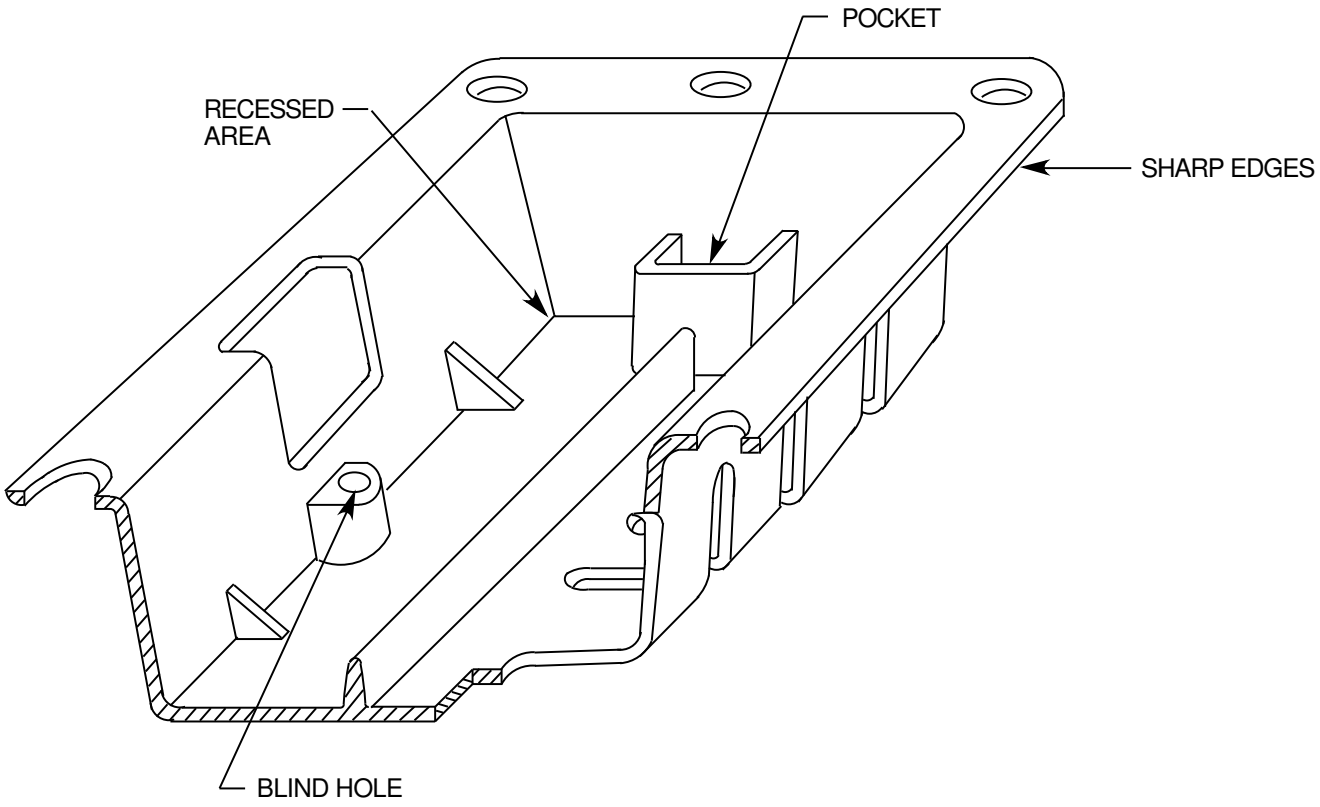


Figure 2–3: Painting Complex Geometry with Enamel and Lacquer



2.2.4 PLATE

INFORMATION

RULE:

Features within the plating process will be divided into the following categories. The order of recommended use is:

- Chrome
- Nickel (not recommended)
- Gold (not recommended)
- Silver (not recommended)
- Copper (not recommended)

REASON/S:

- The relative ranking is based upon cost, technical expertise, and available and approved vendor base.
- Nickel, gold, silver, and copper are susceptible to surface discoloration (such as, fingerprints, tarnishing).
- Gold and silver are expensive plus susceptible to surface discoloration (tarnish).
- These feature categories should support most engineering requirements for finishing (plating) plastic substrates, and will support future AI tool development, for example, The Design Advisor.

ALTERNATIVE/S:

- Paint
- Special coatings
- Mold-in color in base materials

ALTERNATIVE IMPACT: Positive or negative impact of alternatives would have to be evaluated based upon specific design requirements. See a Producibility Engineer.

2.2.5 PLATE—ELECTROLYTIC

INFORMATION

RULE/S:

1. Electrolytic plating is a finishing process with the following characteristics:
   - Has plastic (substrate) material limitations due to the high temperature associated with the plating process
   - May require an electroless undercoat for adhesion
   - Has better abrasion resistance than electroless coatings
   - Preferred for thick coating applications
   - May have bright finish capabilities
   - Has poor paint adhesion capabilities
   - Has size constraints (for instance, large parts may be difficult to get plated)
   - Generally less susceptible to surface discoloration (for instance, finger prints) than electroless plating
2. Irregular surface conditions, blind holes, recessed areas, and so on, can lead to processing problems, such as poor drainage.

NOTE: Refer to DEC STD 092-0 for more specific information.

REASON/S:

- Plating is a high temperature, submersion process.
- Electrolytic plating requires a conductive surface for proper adhesion.
- Process requires good part drainage characteristics.
- Process produces a non-uniform buildup of plating material.
- Process is limited to the physical capabilities of the vendor base (for instance, the plating tank size).
- Irregular surface conditions, blind holes, recessed areas, and so on, can result in poor adhesion or non-uniform coating (thickness and coverage).
- Improve abrasion resistance is due to thickness of plating.

ALTERNATIVE/S:

- Mold-in color in base material
- Paint

- Special coatings

ALTERNATIVE IMPACT: Positive or negative impact of alternative would have to be evaluated based upon specific design requirements. See a Producibility Engineer.

2.2.6 PLATE—COPPER/NICKEL/CHROME (ELECTROLYTIC)

GUIDELINE

RULE/S:

1. Copper/nickel/chrome plating is the preferred finish when aesthetics are required. Figure 2–4.
2. Copper/nickel/chrome (electrolytic) plating is not recommended for parts that have numerous recessed areas (pockets) and blind holes. See Figure 2–4.
3. Copper/nickel/chrome plating is not recommended for surfaces that require painting.
4. Irregular surface conditions, blind holes, recessed areas, and so on, can lead to processing problems, such as poor drainage.
5. Molded-in stress must be avoided.
6. Plastic substrate and the electrolytic chrome process must be compatible. See a Producibility Engineer and DEC STD 092-0 for specific design recommendations.

REASON/S:

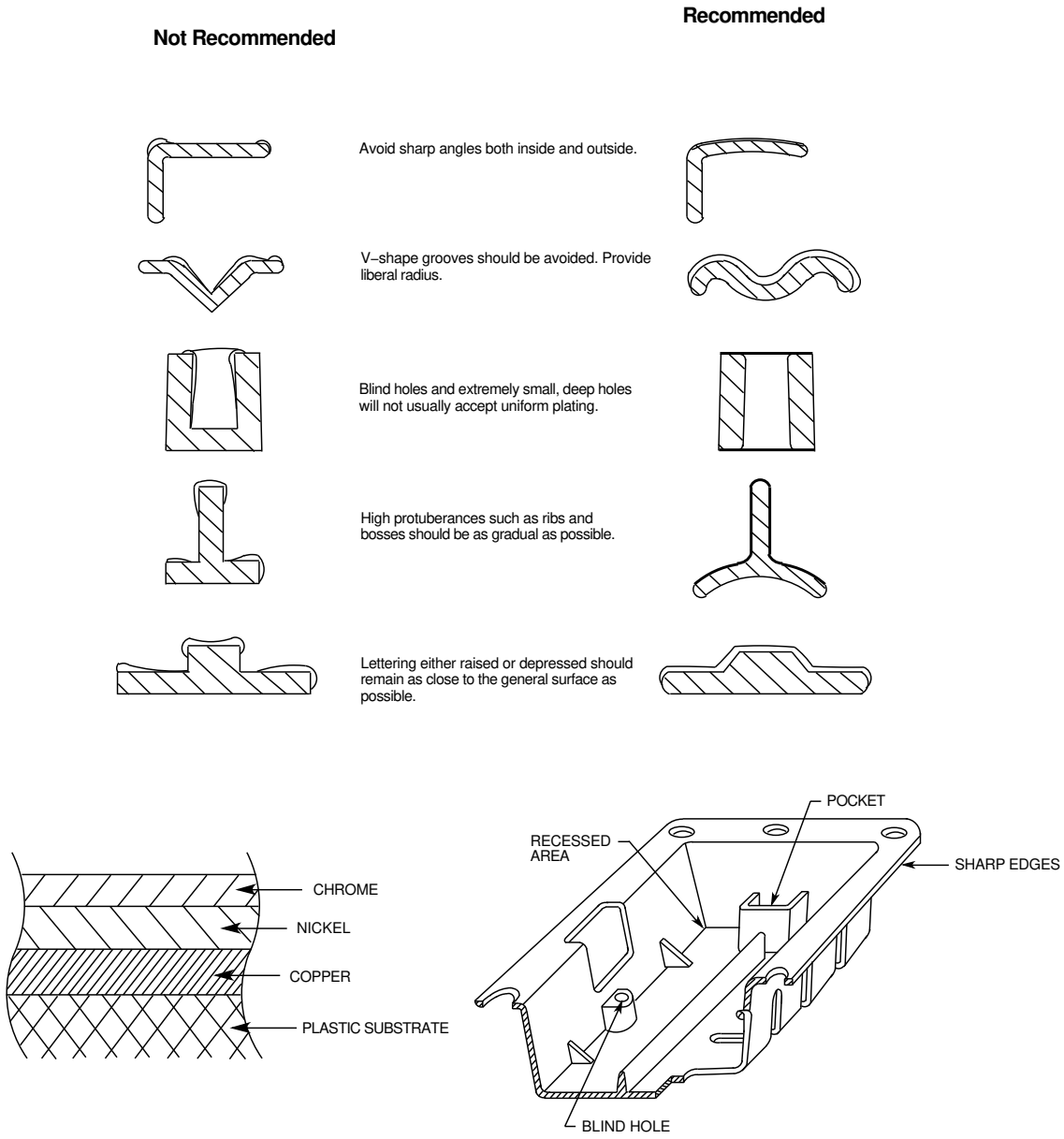
- Irregular surface conditions, sharp edges, blind holes, and so on, can lead to poor adhesion and/or non-uniform plating of plastic substrates.
- Molded-in stress increases the risk of surface cracks leading to improper adhesion of plating and reduced flexibility of base material.
- Chrome has poor paint adhesion capabilities.
- Process requires good part drainage characteristics.

ALTERNATIVE/S:

- Molded-in colors in base materials
- Paint
- Special coatings

ALTERNATIVE IMPACTS: Positive or negative impacts of alternatives would have to be evaluated based upon specific design requirements. See a Producibility Engineer.

Figure 2–4: Electrolytic Plating


Not Recommended
Recommended
Avoid sharp angles both inside and outside.
V–shape grooves should be avoided. Provide liberal radius.
Blind holes and extremely small, deep holes will not usually accept uniform plating.
High protuberances such as ribs and bosses should be as gradual as possible.
Lettering either raised or depressed should remain as close to the general surface as possible.
CHROME
NICKEL
COPPER
PLASTIC SUBSTRATE
POCKET
RECESSED AREA
SHARP EDGES
BLIND HOLE

2.2.7 SPECIAL COATINGS

INFORMATION

RULE:

Features within the special coating process will be divided into the following categories normally used for multicolor, lettering, and graphic applications.

- Silk screening
- Vacuum deposition
- Pad printing
- Hot stamping
- Flame/arc spray normally used for metal-like appearance (generally not recommended)

NOTE: Refer to DEC STD 092-0 for more specific information. Due to the process characteristics of the above special coatings, see a Producibility Engineer for specific design recommendations.

REASON/S:

- There are other more cost-effective methods of coating (plating) plastics.
- These feature categories should support most engineering requirements for finishing (special coatings) plastic substrates, and will support future AI tool development, for example, The Design Advisor.

ALTERNATIVE/S:

- Molded-in color in base material
- Paint
- Plating

ALTERNATIVE IMPACT: Positive or negative impacts of alternatives would have to be evaluated based upon specific design requirements. See a Producibility Engineer.

2.2.8 SPECIAL COATINGS—SILK SCREENING

GUIDELINE

RULE/S:

1. Silk screening is effective for multicolored applications.
2. Silk screening is effective on raised or multiple (same plane) surface.
3. Silk screening is an effective means of applying lettering and graphics. See Figure 2–5.

REASON/S:

- The silk screening process has good registration and fine detailing capabilities.
- Silk screening has masking capabilities built into the process.

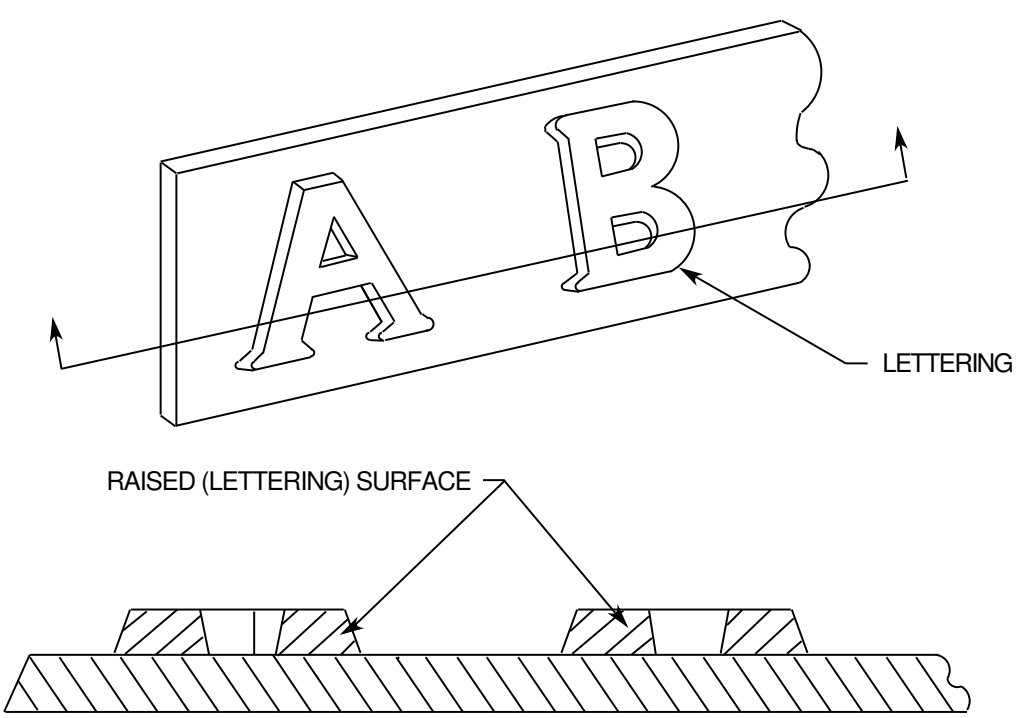
ALTERNATIVE/S:

- Labels
- Pad printing
- Mask and paint
- Hot stamping

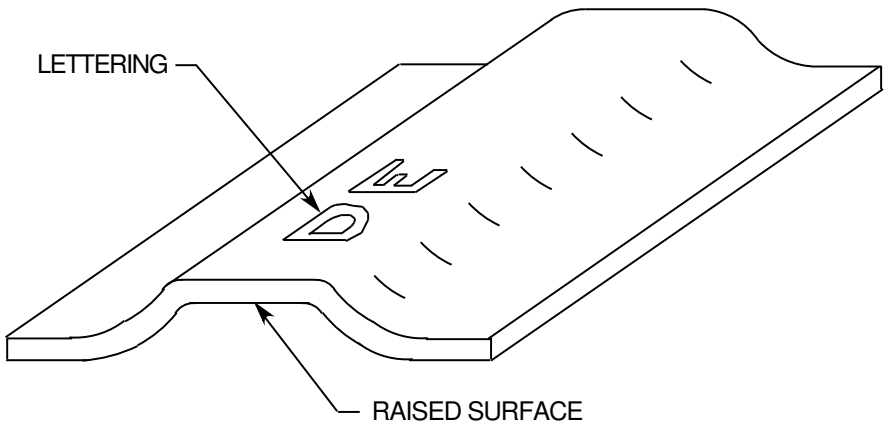
ALTERNATIVE IMPACT: Positive or negative impacts of the alternatives would have to be evaluated based upon specific design requirements. See a Producibility Engineer.

Figure 2–5: Special Coatings—Silk Screening

A



B



2.2.9 SPECIAL COATING—PAD PRINTING

GUIDELINE

RULE/S:

1. Pad printing is effective for multicolored applications.
2. Pad printing is effective for raised or multiple (same plane) surfaces. See Figure 2–6.
3. Pad printing is an effective means of applying lettering and graphics.
4. The process has size limitations. See a Producibility Engineer.

REASON/S:

- The pad printing process has good registration and fine detailing capabilities.
- Pad printing has masking capabilities built into the process.
- The process is limited to the physical size of the equipment and/or pads.

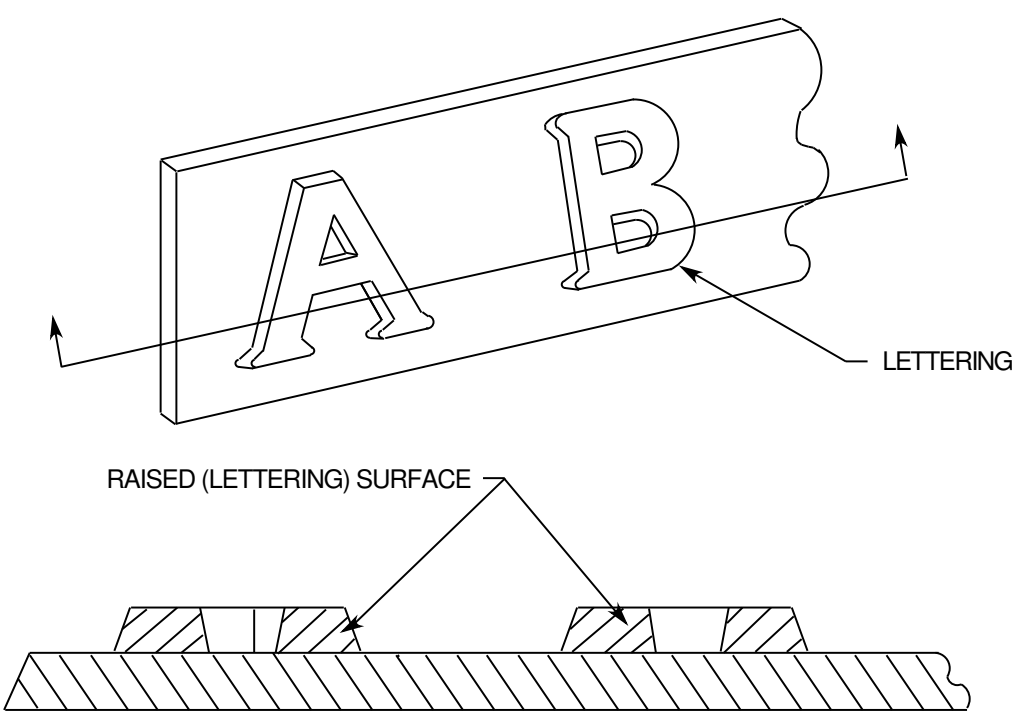
ALTERNATIVE/S:

- Labels
- Silk screening
- Mask and paint
- Hot stamping

ALTERNATIVE IMPACT: Positive or negative impacts of alternatives would have to be evaluated based upon specific design requirements. See a Producibility Engineer.

Figure 2–6: Special Coating—Pad Printing

A



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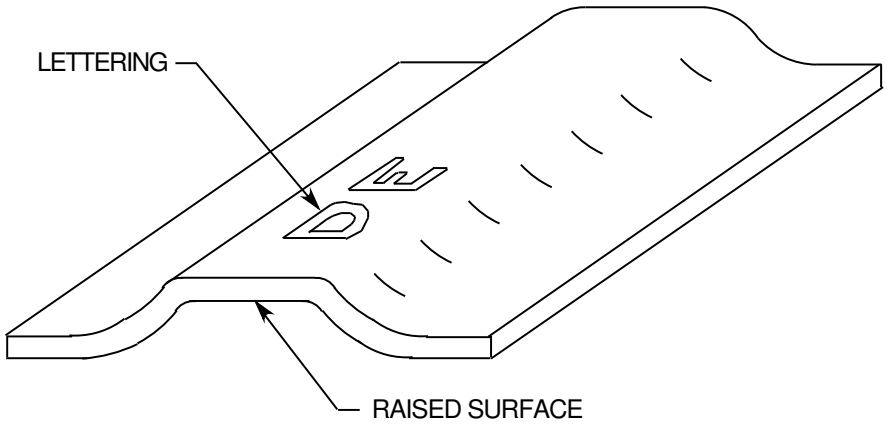


2.2.10 SPECIAL COATING—HOT STAMPING

GUIDELINE

RULE/S:

1. Hot stamping is effective for multicolored applications.
2. Hot stamping is effective for raised or multiple (same plane) surfaces. See Figure 2–7.
3. Hot stamping is an effective means of applying lettering and graphics.
4. Side walls cannot be hot stamped.
5. The process has size limitations. See a Producibility Engineer.

REASON/S:

- The hot stamping process has good registration and fine detailing.
- Hot stamping has masking capabilities built into the process.
- The process is limited to the physical size of the equipment and/or stamps.

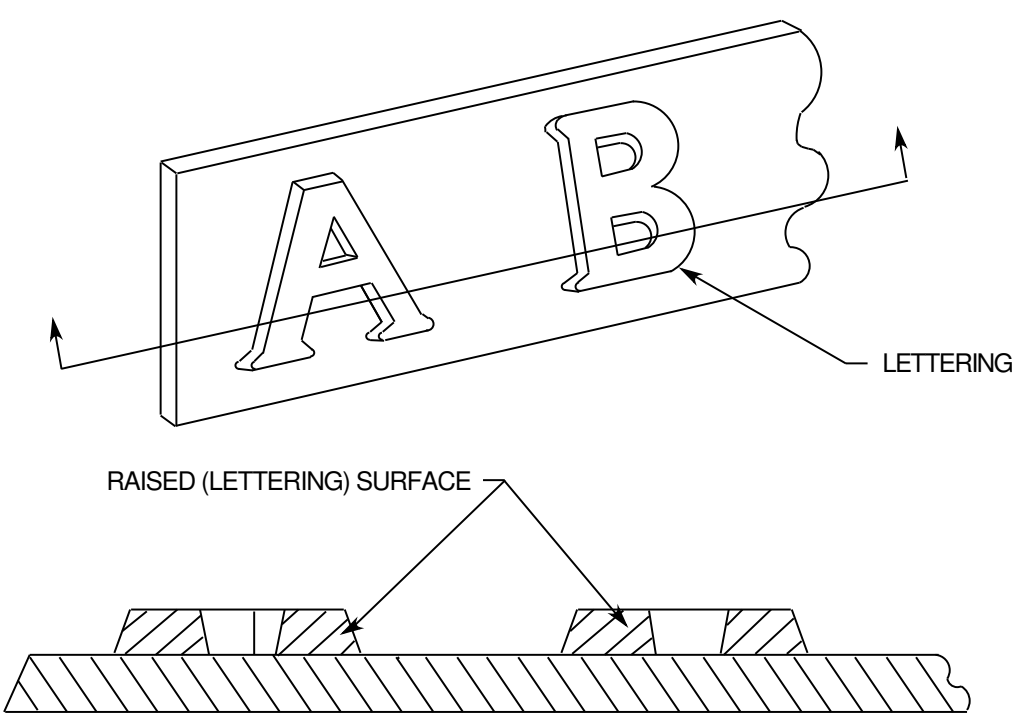
ALTERNATIVES/S:

- Labels
- Silk screening
- Mask and paint
- Pad printing

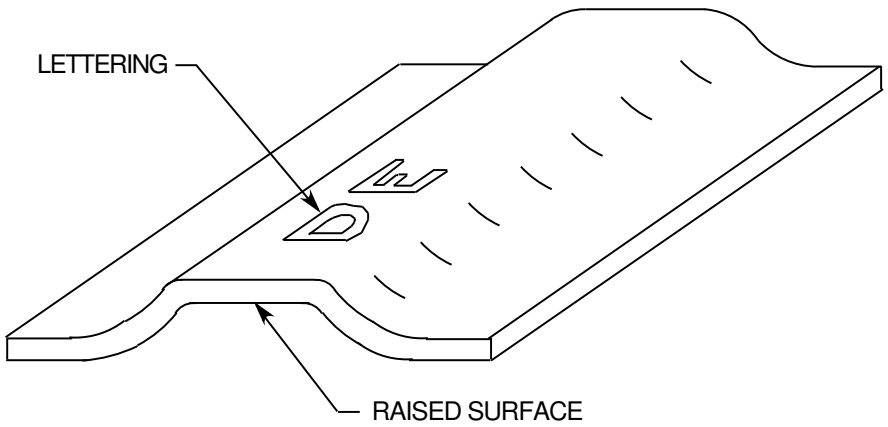
ALTERNATIVE IMPACT: Positive or negative impacts of alternatives would have to be evaluated based upon specific design requirements. See a Producibility Engineer.

Figure 2–7: Special Coatings—Hot Stamping

A



B



2.2.11 SPECIAL COATINGS—VACUUM DEPOSITION

GUIDELINE

RULE/S:

1. Irregular surface conditions, blind holes, recessed areas, and so on, can lead to processing problems. See Figure 2–8.
2. Generally, aluminum with clear coat is used for cosmetic applications.
3. The process has size limitations. See a Producibility Engineer.

REASON/S:

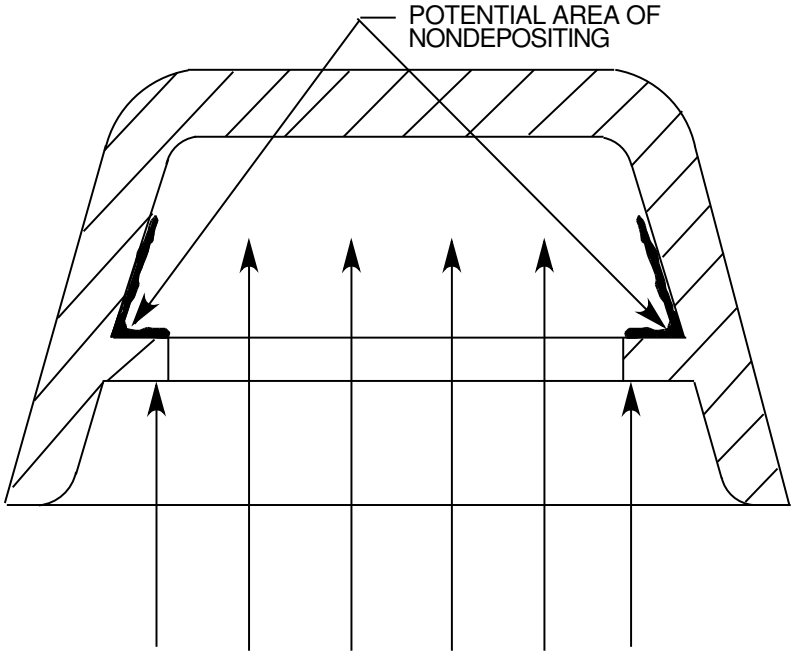
- Vacuum deposition is applied using a vapor process (not spray or immersion).
- The vacuum deposition process requires that all surfaces are accessible to the metal vapor.
- The process is limited to the physical capabilities of the *limited* vendor base (for instance, the vacuum chamber size).
- Irregular surface conditions, blind holes, recessed areas, and so on, can result in poor adhesion or non-uniform coating (thickness and coverage).

ALTERNATIVE/S:

- Paint
- Plating
- Flame/arc spray

ALTERNATIVE IMPACT: Positive or negative impacts of the alternatives would have to be evaluated based upon specific design requirements. See a Producibility engineer.

Figure 2–8: Vacuum Deposition



2.2.12 TEXTURING

INFORMATION

RULE/S:

1. Texturing can best be achieved through the molded-in process, such as texturing the mold.
2. When plating, texturing can *only* be achieved by plating over a pretextured plastic (substrate) surface.
3. It must be understood that molding in textures do "not" necessarily match paint applied textures. See a Producibility Engineer and DEC STD 092-0 for specific design recommendations.
4. Texturing can be achieved by applying a smooth coat of paint over a pretextured plastic substrate.

REASON/S:

- Painting of plastics (substrates) is a standard manufacturing process readily available over a large vendor base.
- Texturing (per DEC STD 092-0) *cannot* be achieved by means of a plating process.
- Most economical method of applying a texture on plastic substrate using molded-in texture and color.

ALTERNATIVE: Not applicable

ALTERNATIVE IMPACT: Not applicable

2.3 FINISHING—SHIELDING

2.3.1 PAINT/PLATE/SPECIAL COATINGS

INFORMATION

RULE/S:

1. Painting is a finishing option when the following criteria must be met:
   - Shielding characteristics are *not* available in base material
   - Electrostatic discharge (ESD) characteristics are *not* available in base material
2. Plating is a finishing option when the following criteria must be met:
   - Shielding characteristics are *not* available in base material
   - Electrostatic discharge (ESD) characteristics are *not* available in base material.
3. Special coatings is a finishing option when the following criteria must be met:
   - Special EMI/RFI conditions

     NOTE: Shielding effectiveness is the result of many design aspects (for instance, component configurations, part geometry, coating thickness, and so on).

     If ESD is the only design requirement, use precompounded materials.

REASON/S:

- Painting of plastics is an (acceptable) standard manufacturing process readily available over a large vendor base.
- Plating of plastics is less available as a manufacturing process and should be used *only* when no other options are acceptable.
- Coatings have been developed to satisfy special shielding and/or ESD conditions. See a Producibility Engineer for specific design requirements.

ALTERNATIVE: Mold-in shielding and/or ESD properties.

ALTERNATIVE IMPACT: Positive or negative impacts of alternative would have to be evaluated based upon specific design requirements. Refer to Producibility Engineer.

2.3.2 PAINT

INFORMATION

RULE:

Features within the paint process will be divided into the following categories. The order of recommended use is:

- Lacquers (nickel and copper acrylic paints)
- Enamels (not recommended)

NOTE: The relative ranking is based upon technical expertise and availability of approved vendor base.

Refer to DEC STD 092-0 for more specific information.

REASON: These feature categories should support most engineering requirements for finishing (shielding) plastic substrates, and will support future AI tool development, for example, The Design Advisor.

ALTERNATIVE/S:

- Molded-in compounds in base materials
- Plating
- Special coatings

ALTERNATIVE IMPACT: Positive or negative impacts of alternatives would have to be evaluated based upon specific design requirements. See a Producibility Engineer.

2.3.3 PAINT—LACQUER

GUIDELINE

RULE/S:

1. Lacquers (nickel and copper acrylic paints) are normally used to provide low levels of electrical shielding.
2. The plastic substrate and lacquer *must* be compatible. See a Producibility Engineer and DEC STD 092-0 for specific design recommendations.
3. Lacquers may not be effective for shielding applications when parts have irregular surface conditions, numerous recessed areas (pockets) or, blind holes. See Figure 2–9.
4. Lacquers have to be specially formulated in order to meet shielding requirements, usually by the addition of nickel or copper particles.

   NOTE: Primer coat(s) may be required to satisfy proper coverage and/or adhesion. See a Producibility Engineer for specific design recommendations

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REASON/S:

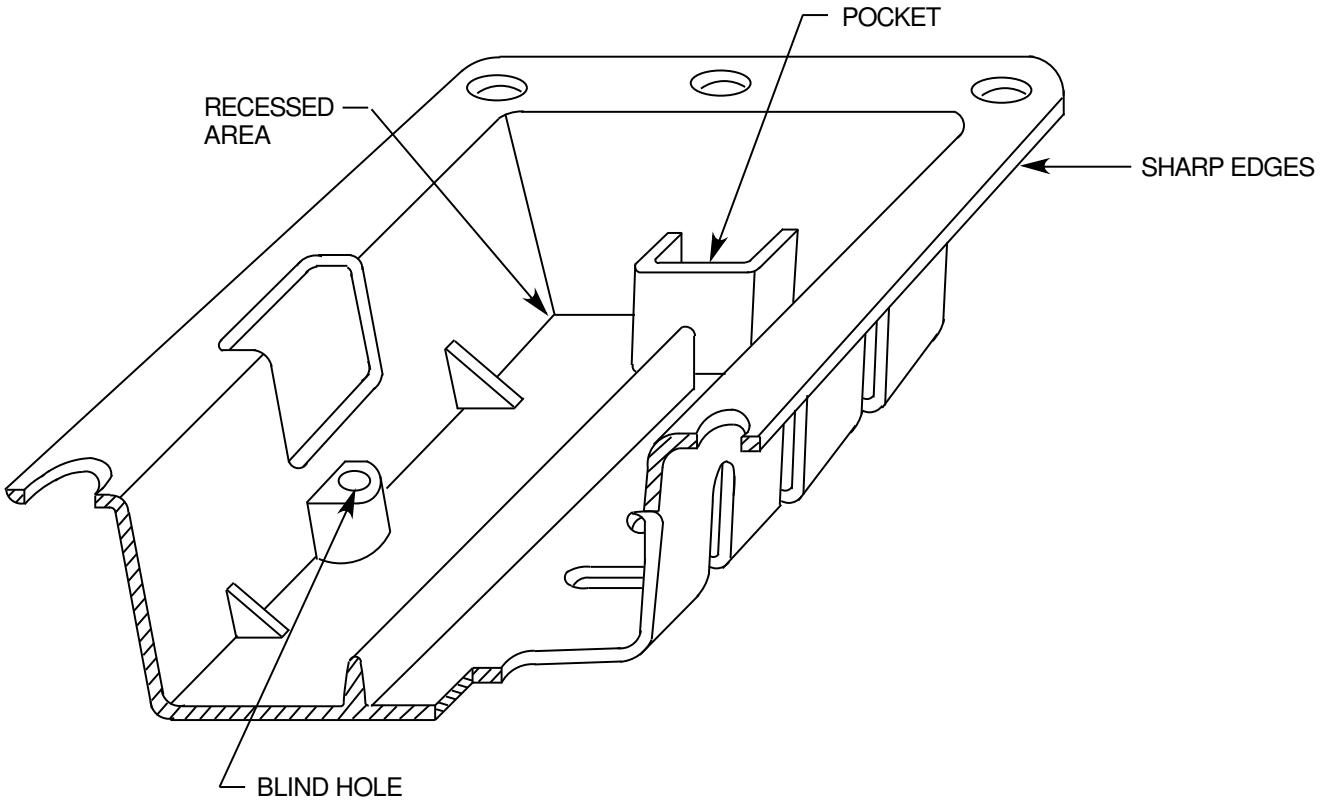
- Lacquers are solvent based and can lead to dissolving of the base material (substrate), which may have a detrimental effect on the product specifications.
- Irregular surface conditions, recessed areas (pockets), or blind holes can lead to poor adhesion and/or nonuniform coating.
- Lacquers are applied using a spraying process (not immersion).

ALTERNATIVE/S:

- Molded-in compounds in base materials
- Plating
- Special coatings

ALTERNATIVE IMPACT: Positive or negative impacts of alternatives would have to be evaluated based upon specific design requirements. See a Producibility Engineer.

Figure 2–9: Sheilding Paint—Lacquer



2.3.4 PLATE

INFORMATION

RULE/S:

1. Features within the plating process will be divided into the following categories. The order of recommended use is:
   - Copper/nickel electroless
   - Copper/nickel electrolytic
   - Copper/tin (not recommended)
   - Copper/nickel/chrome (not recommended)
   - Copper (not recommended)
   - Chrome (not recommended)
   - Gold (not recommended)
   - Silver (not recommended)

   NOTE: The relative ranking is based upon technical expertise and availability approved vendor base.

   Refer to DEC STD 092-0 for more specific information.

REASON/S:

- Gold, silver, and tin are not recommended since there are more cost-effective methods available for shielding plastics.
- Chrome is not recommended due to its low electrical surface conductivity.
- Copper is not recommended due to its susceptibility to tarnish.
- These feature categories should support all engineering requirements for finishing (shielding) plastic substrates and will support future AI tool development, for example, The Design Advisor.

ALTERNATIVE/S:

- Special coatings
- Paints
- Molded-in compounds in base material

ALTERNATIVE IMPACT: Positive or negative impacts of alternatives would have to be evaluated based upon specific design requirements. See a Producibility Engineer.

2.3.5 PLATE—ELECTROLESS

INFORMATION

RULE/S:

1. Electroless plating is a finishing process with the following characteristics:
   - Has plastic (substrate) material limitations due the high temperature associated with the plating process.
   - Has less abrasion resistance than electrolytic coatings.
   - Generally, a more cost-effective process than electrolytic.
   - Process creates a dull surface finish and is susceptible to surface discoloration (for instance, finger prints).
   - Has paint adhesion capabilities.
   - Primarily used in shielding applications.
   - Preferred for parts with complex geometry, recessed areas (pockets), or blind holes.
   - Has size constraints (for instance, large parts may be difficult to plate).
   - Plated finish appearance is dictated by the surface to which it is applied.

     NOTE: Refer to DEC STD 092-0 for more specific information.

REASON/S:

- Plating is a high temperature submersion process.
- Electroless plating requires a preconditioned surface for proper adhesion.
- Process requires good part drainage characteristics.
- Electroless is a nonleveling type plating process.
- The process is limited to the physical capabilities of the vendor base (for instance, the plating tank size).
- Low abrasion resistance is due to thickness of plating.

ALTERNATIVE/S:

- Electrolytic plating
- Paint
- Special coatings

- Molded-in compounds in base materials

ALTERNATIVE IMPACT: Positive or negative impact of the alternative would have to be evaluated based upon specific design requirements. See a Producibility Engineer.

2.3.6 PLATE—COPPER/NICKEL (ELECTROLESS)

GUIDELINE

RULE/S:

1. This finish is preferred rather than nickel and copper acrylic paints when better electrical surface conductivity is required.
2. Molded-in stress must be avoided.
3. Plastic substrate and electroless nickel process must be compatible. See a Producibility Engineer and DEC STD 092-0 for specific design recommendations.
4. Irregular surface conditions, blind holes, recessed areas, and so on, can lead to processing problems, such as poor drainage. See a Producibility Engineer for specific design recommendations. See Figure 2–10.
5. Has good paint adhesion capabilities.

REASON/S:

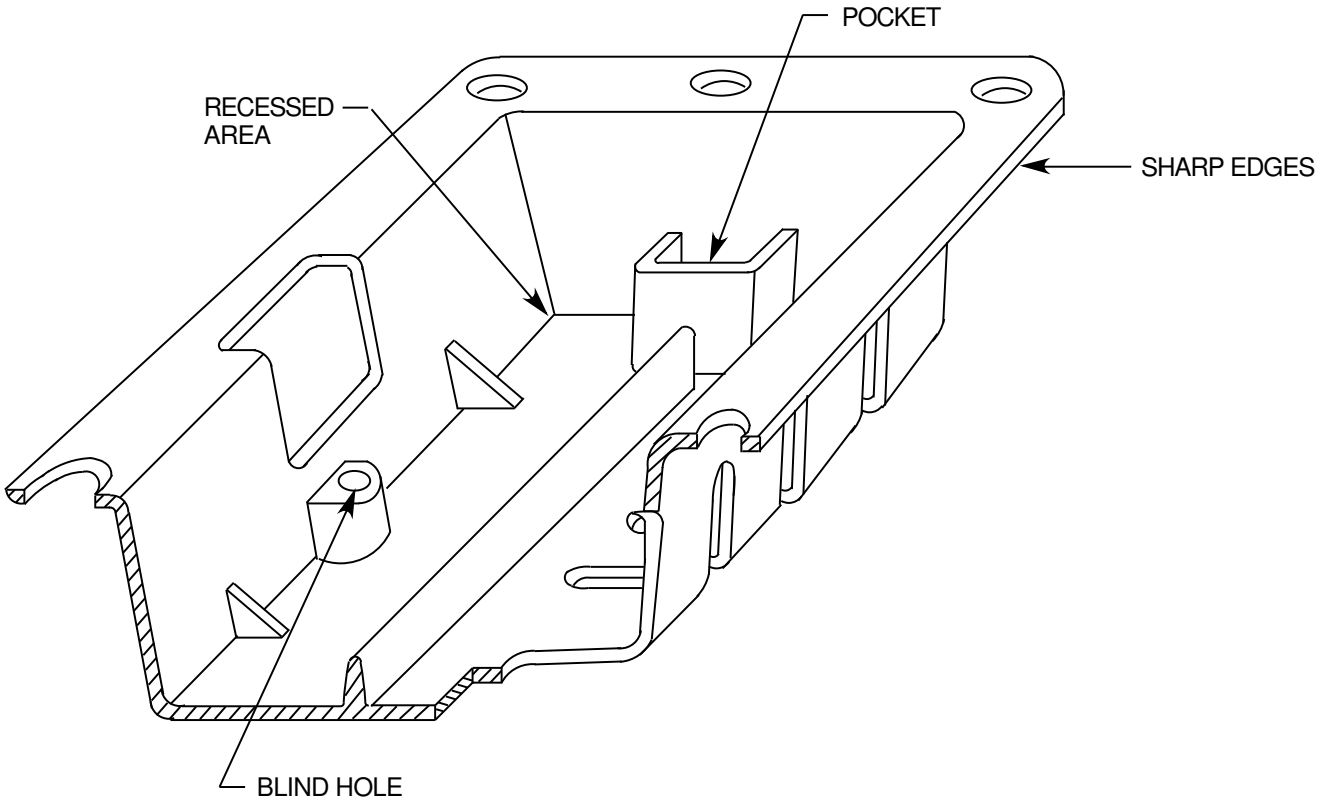
- Recessed areas (pockets) and/or blind holes can lead to poor adhesion and/or nonuniform plating of plastic substrates.
- Molded-in stress results in improper adhesion of plating.
- Process requires good part drainage.
- Irregular surface conditions, blind holes and so on, can result in poor adhesion or non-uniform coating (thickness and coverage). See Figure 2–10.

ALTERNATIVE/S:

- Mold-in compounds in base materials
- Copper/nickel (electrolytic) plate
- Paints
- Special coating

ALTERNATIVE IMPACTS: Positive or negative impacts of alternatives would have to be evaluated based upon specific design requirements. See a Producibility Engineer.

Figure 2–10: Plate—Copper/Nickel (Electroless)



2.3.7 PLATE—ELECTROLYTIC

INFORMATION

RULE/S:

1. Electrolytic plating is a finishing process with the following characteristics:
   - Has plastic (substrate) material limitations due to the high temperature associated with the plating process
   - May require an electroless undercoat for adhesion
   - Has better abrasion resistance than electroless coatings
   - Preferred for thick coating applications
   - May have bright finish capabilities
   - Has poor paint adhesion capabilities
   - Has size constraints (for instance, large parts may be difficult to get plated)
   - Generally less susceptible to surface discoloration (for instance, finger prints) than electroless plating
2. Irregular surface conditions, blind holes, recessed areas, and so on, can lead to processing problems, such as poor drainage.

NOTE: Refer to DEC STD 092-0 for more specific information.

REASON/S:

- Plating is a high temperature, submersion process.
- Electrolytic plating requires a conductive surface for proper adhesion.
- Process requires good part drainage characteristics.
- Process produces a non-uniform buildup of plating material.
- Process is limited to the physical capabilities of the vendor base (for instance, the plating tank size).
- Irregular surface conditions, blind holes, recessed areas, and so on, can result in poor adhesion or non-uniform coating (thickness and coverage).
- Improve abrasion resistance is due to thickness of plating.

ALTERNATIVE/S:

- Mold-in color in base material
- Paint

- Special coatings

ALTERNATIVE IMPACT: Positive or negative impact of alternative would have to be evaluated based upon specific design requirements. See a Producibility Engineer.

2.3.8 PLATE—COPPER/NICKEL (ELECTROLYTIC)

GUIDELINE

RULE/S:

1. This finish is preferred over nickel and copper acrylic paints when better electrolytic finish surface conductivity is required.
2. Irregular surface conditions, blind holes, recessed areas, and so on, can lead to processing problems (such as, poor drainage areas). See Figure 2–11.
3. Molded-in stress must be avoided.
4. Plastic substrate and electrolytic nickel process must be compatible. See a Producibility Engineer and DEC STD 092-0 for specific design recommendations.
5. Electrolytic is preferred over electroless when wearability and cosmetics are required.
6. This finish has poor paint adhesion capability.

REASON/S:

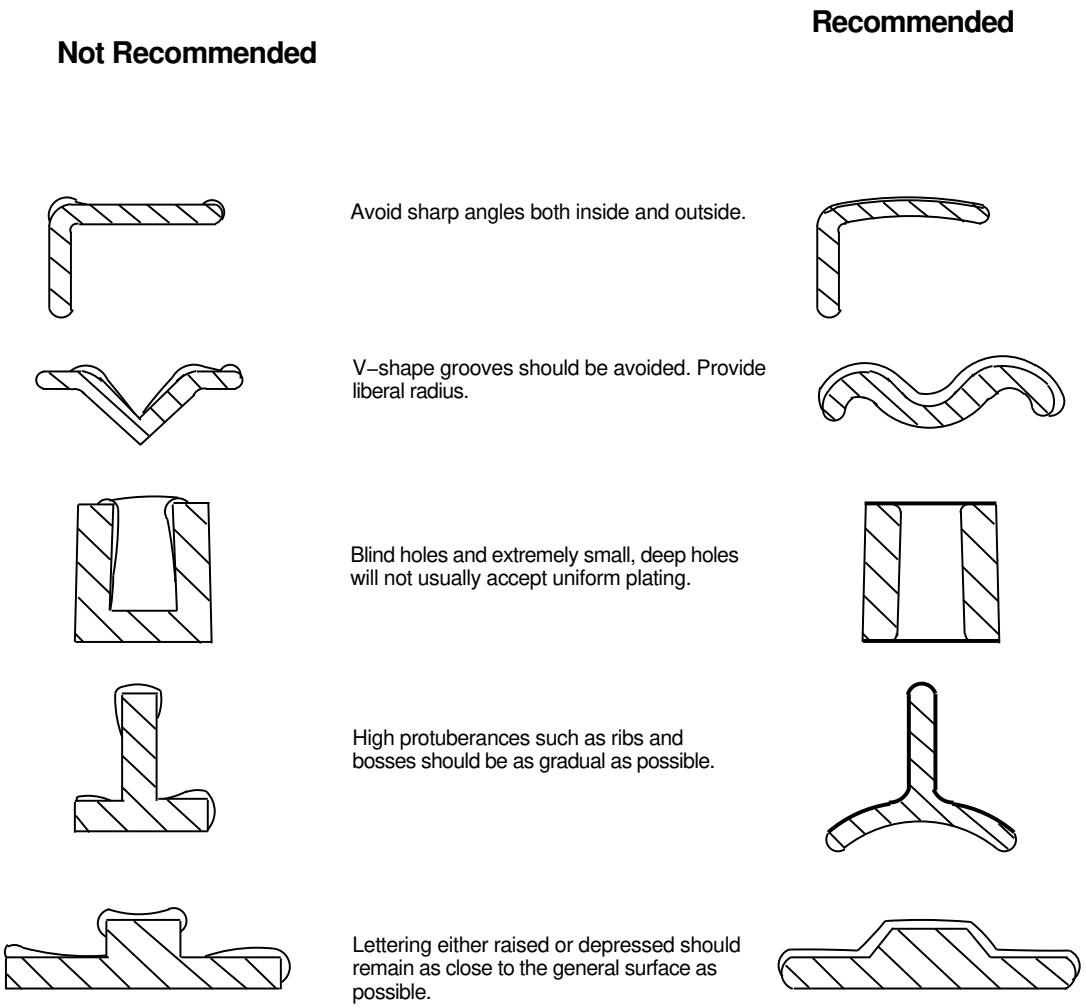
- Irregular surface conditions, blind holes, recessed areas, and so on, can result in poor adhesion or non-uniform coating (thickness and coverage). See Figure 2–11.
- Molded-in stress results in improper adhesion of plating.
- Process requires good part drainage requirements.

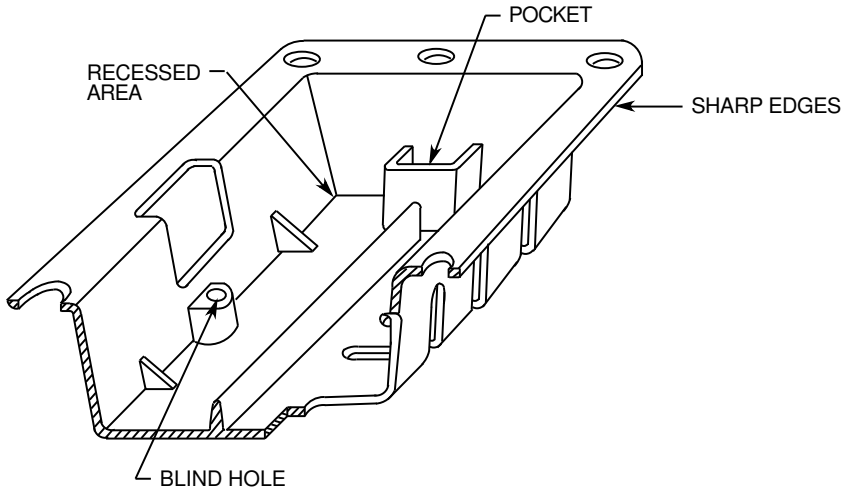
ALTERNATIVE/S:

- Mold-in compounds in base materials
- Copper/nickel (electroless) plate
- Paints
- Special coatings

ALTERNATIVE IMPACTS: Positive or negative impacts of alternatives would have to be evaluated based upon specific design requirements. See a Producibility Engineer.

Figure 2–11: Plate—Copper/Nickel (Electrolytic)


Not Recommended
Recommended
Avoid sharp angles both inside and outside.
V–shape grooves should be avoided. Provide liberal radius.
Blind holes and extremely small, deep holes will not usually accept uniform plating.
High protuberances such as ribs and bosses should be as gradual as possible.
Lettering either raised or depressed should remain as close to the general surface as possible.



2.3.9 SPECIAL COATINGS

INFORMATION

RULE:

Features within the special coating process will be divided into the following categories.

- Vacuum deposition
- Flame/arc spray (not recommended)

  NOTE: Refer to DEC STD 092-0 for more specific information.

REASON/S:

- These feature categories should support most engineering requirements for finishing (shielding) plastic substrates and will support future AI tool development, such as, The Design Advisor.
- There are possible environmental impacts associated with the arc spray process. See a Producibility Engineer for specific guidelines and recommendations.
- There are more cost-effective methods to shield plastic substrates.

ALTERNATIVE/S:

- Plating
- Paint
- Molded-in compounds in base materials

ALTERNATIVE IMPACT: Positive or negative impacts of alternatives would have to be evaluated based upon specific design requirements. See a Producibility Engineer.

2.3.10 SPECIAL COATINGS—VACUUM DEPOSITION

GUIDELINE

RULE/S:

1. Irregular surface conditions, blind holes, recessed areas, and so on, can lead to processing problems. See Figure 2–12.
2. Generally, aluminum is used for shielding applications.
3. The process has size limitations. See a Producibility Engineer.

REASON/S:

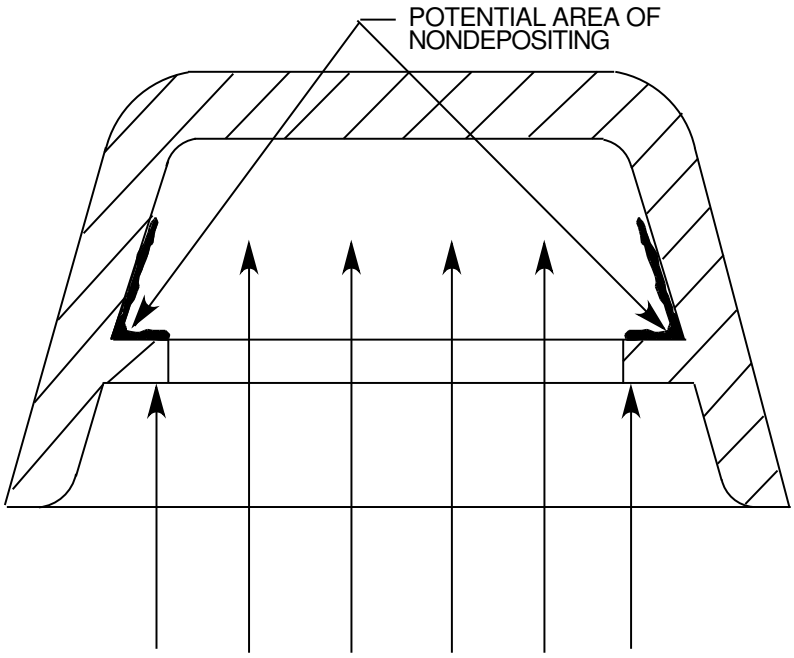
- Vacuum deposition is applied using a vapor process (not spray or immersion).
- The vacuum deposition process requires that all surfaces are accessible to the metal vapor.
- The process is limited to the physical capabilities of the limited vendor base (for instance, the vacuum chamber size).
- Irregular surface conditions, blind holes, recessed areas, and so on, can result in poor adhesion or non-uniform coating (thickness and coverage). See Figure 2–12.

ALTERNATIVE/S:

- Flame/arc spray
- Plating
- Paint

ALTERNATIVE IMPACT: Positive or negative impacts of alternatives would have to be evaluated based upon specific design requirements. See a Producibility Engineer.

Figure 2–12: Vacuum Deposition



2.4 FINISHING—PROTECTION

2.4.1 PAINT/PLATE/SPECIAL COATINGS

INFORMATION

RULE/S:

1. Painting is used for surface protection applications, such as, UV stability, solvent resistance, gloss control, when not available in base material.
2. Plating is not recommended for protection of plastic substrates.
3. Special coatings are not recommended for protection of plastics.

REASON/S:

- Painting of plastics is an (acceptable) standard manufacturing process readily available over a large vendor base.
- Plating of plastics is less available as a manufacturing process.
- Special coatings may not be readily available. See a Producibility Engineer.

ALTERNATIVE:

Molded-in protection characteristics in base materials

ALTERNATIVE IMPACT: Positive or negative impacts of alternatives would have to be evaluated based upon specific design requirements. See a Producibility Engineer.

2.4.2 PAINT

INFORMATION

RULE/S:

Features within the paint process will be divided into the following categories. The order of recommended use is:

- Enamels
- Lacquers (acrylics)

NOTE: Refer to DEC STD 092-0 for more specific information.

REASON/S:

- These feature categories should support most engineering requirements for finishing plastic substrates and will support future AI tool development, for example, The Design Advisor.
- The relative ranking is based on cost, technical expertise, and available /approved vendor base.

ALTERNATIVES:

- Molded-in characteristics in base material
- Plating
- Special coatings

ALTERNATIVE IMPACT: Positive or negative impacts of alternatives would have to be evaluated based upon specific design requirements. See a Producibility Engineer.

2.4.3 PAINT—ENAMEL/LACQUER

GUIDELINE

RULE/S:

1. Irregular surface conditions, blind holes, recessed areas, and so on, can lead to processing problems, such as non-uniform coating. See Figure 2–14.
2. The plastic substrate and enamel *must* be compatible. See a Producibility Engineer and DEC STD 092-0 for specific design recommendations.
3. Lacquers are generally used for prototype development and not volume manufacturing.
4. Enamels are *not* effective for hiding base material (substrate) surface irregularities, for instance, structural foam parts.
5. Enamels are recommended for most cosmetic applications.
6. Primer coat(s) may be required to satisfy proper coverage and/or adhesion. See a Producibility Engineer for specific design recommendations.

   NOTE: Transition features should be designed into a multicolored painted part to facilitate ease of color blending. See Figure 2–13.

REASON/S:

- Enamels are solvent based and can lead to dissolving of the base material (substrate), which may have a detrimental effect on the product specifications.
- Enamels and lacquer are applied using a spraying process (not immersion).
- Irregular surface conditions, blind holes, recessed areas, and so on, can result in poor adhesion or non-uniform coating (thickness and coverage). See Figure 2–14.

ALTERNATIVE/S:

- Mold-in characteristics in base material
- Plating
- Special coatings

ALTERNATIVE IMPACT: Positive or negative impact of alternatives would have to be evaluated based upon specific design requirements. See a Producibility Engineer.

Figure 2–13: Transition Features—Enamel/Lacquer

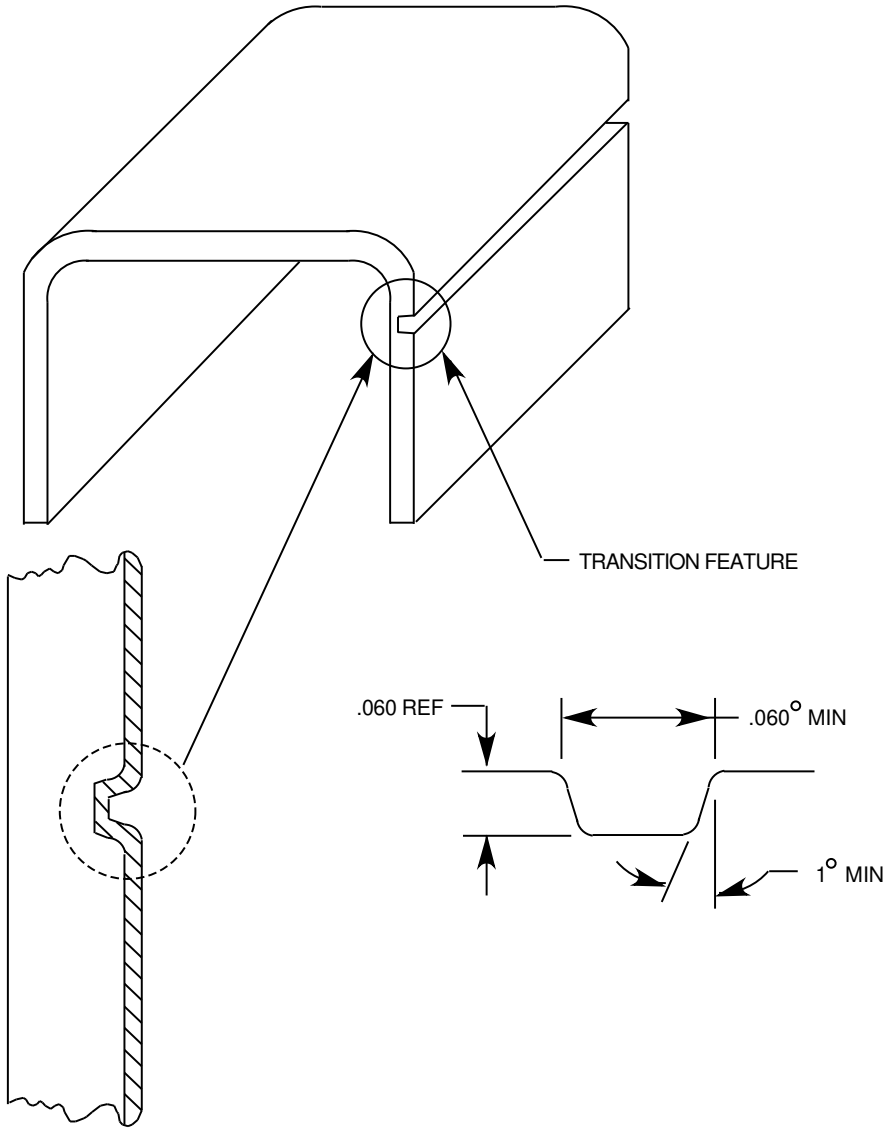
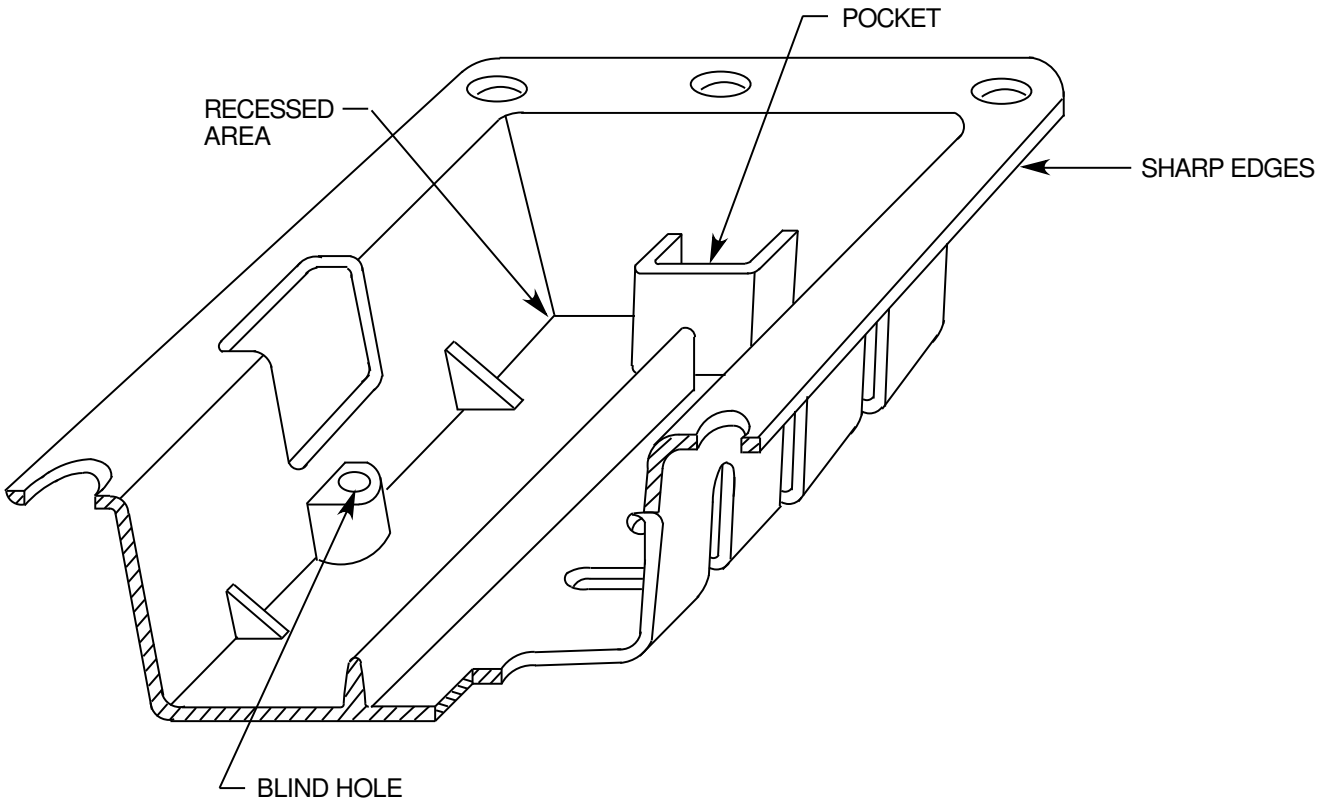


Figure 2–14: Protection Enamel/Lacquer



2.5 FINISHING—WEARABILITY

2.5.1 PAINT/PLATE/SPECIAL COATINGS

INFORMATION

RULE/S:

1. Painting is a finishing option when the following criteria must be met:
   - Acceptable abrasion resistance is *not* available in base material or initial process (for instance, hard coats are usually an acceptable means of protecting silk-screened or hot-stamped surfaces)
2. Plating is a finishing option when the following criteria must be met:
   - Acceptable abrasion resistance is *not* available in base material
   - Special (increased or decreased) friction requirements
3. Special coatings is a finishing option when the following criteria must be met:
   - Acceptable abrasion resistance is *not* available in base material
   - Special (increased or decreased) friction requirements

REASON/S:

- Painting of plastics is an acceptable standard manufacturing process readily available over a large vendor base.
- Plating of plastics is less available as a manufacturing process and should be used *only* when no other options are available for prolonged (extended) surface life (appearance) is required.
- Coatings have been developed to satisfy special abrasion and/or frictional requirements. See a Producibility Engineer for specific design requirements.

ALTERNATIVE/S:

Mold-in characteristics

ALTERNATIVE IMPACT: Positive or negative impacts of alternatives would have to be evaluated based upon specific design requirements. See a Producibility Engineer.

2.5.2 PAINT

INFORMATION

RULE/S:

Features within the paint process will be divided into the following categories. The order of recommended use is:

- Enamel
- Lacquer

NOTE: Refer to DEC STD 092-0 for more specific information.

REASON/S:

- The relative ranking is based upon cost, technical expertise, and available/approved vendor base.
- These feature categories should support most engineering requirements for finishing (wearability of) plastic substrates and will support future AI tool development, for example, The Design Advisor.

ALTERNATIVE/S:

- Plating
- Special coatings
- Molded-in characteristics in base material

ALTERNATIVE IMPACT: Positive or negative impacts of alternatives would have to be evaluated based upon specific design requirements. See a Producibility Engineer.

2.5.3 PAINT—ENAMEL/LACQUER

GUIDELINE

RULE/S:

1. Irregular surface conditions, blind holes, recessed areas, and so on, can lead to processing problems, such as non-uniform coating. See Figure 2–16.
2. The plastic substrate and enamel *must* be compatible. See a Producibility Engineer and DEC STD 092-0 for specific design recommendations.
3. Lacquers are generally used for prototype development and not volume manufacturing.
4. Enamels are *not* effective for hiding base material (substrate) surface irregularities, for instance, structural foam parts.
5. Enamels are recommended for most cosmetic applications.
6. Primer coat(s) may be required to satisfy proper coverage and/or adhesion. See a Producibility Engineer for specific design recommendations.

   NOTE: Transition features should be designed into a multicolored painted part to facilitate ease of color blending. See Figure 2–15.

REASON/S:

- Enamels are solvent based and can lead to dissolving of the base material (substrate), which may have a detrimental effect on the product specifications.
- Enamels and lacquer are applied using a spraying process (not immersion).
- Irregular surface conditions, blind holes, recessed areas, and so on, can result in poor adhesion or non-uniform coating (thickness and coverage). See Figure 2–16.

ALTERNATIVE/S:

- Molded-in characteristics
- Plating
- Special coatings

ALTERNATIVE IMPACT: Positive or negative impact of alternatives would have to be evaluated based upon specific design requirements. See a Producibility Engineer.

Figure 2–15: Wearability Transition Features—Enamel/Lacquer

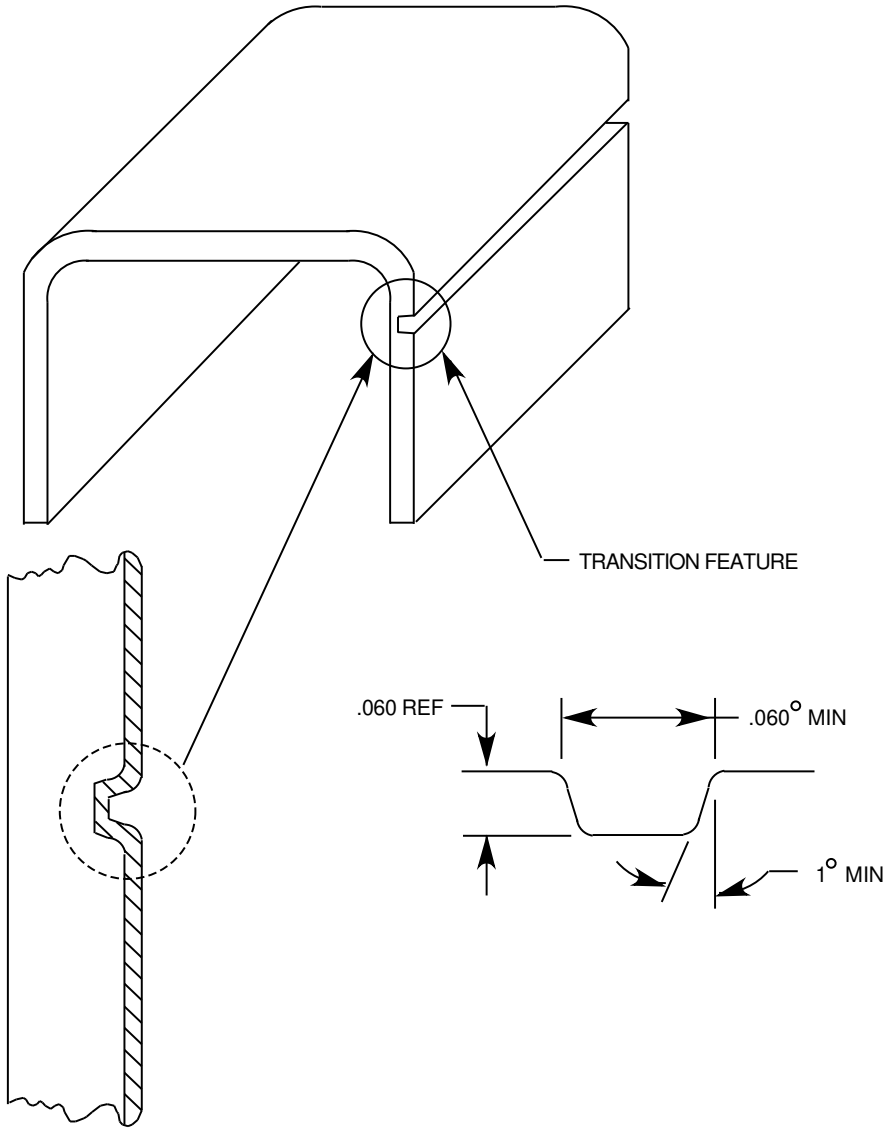
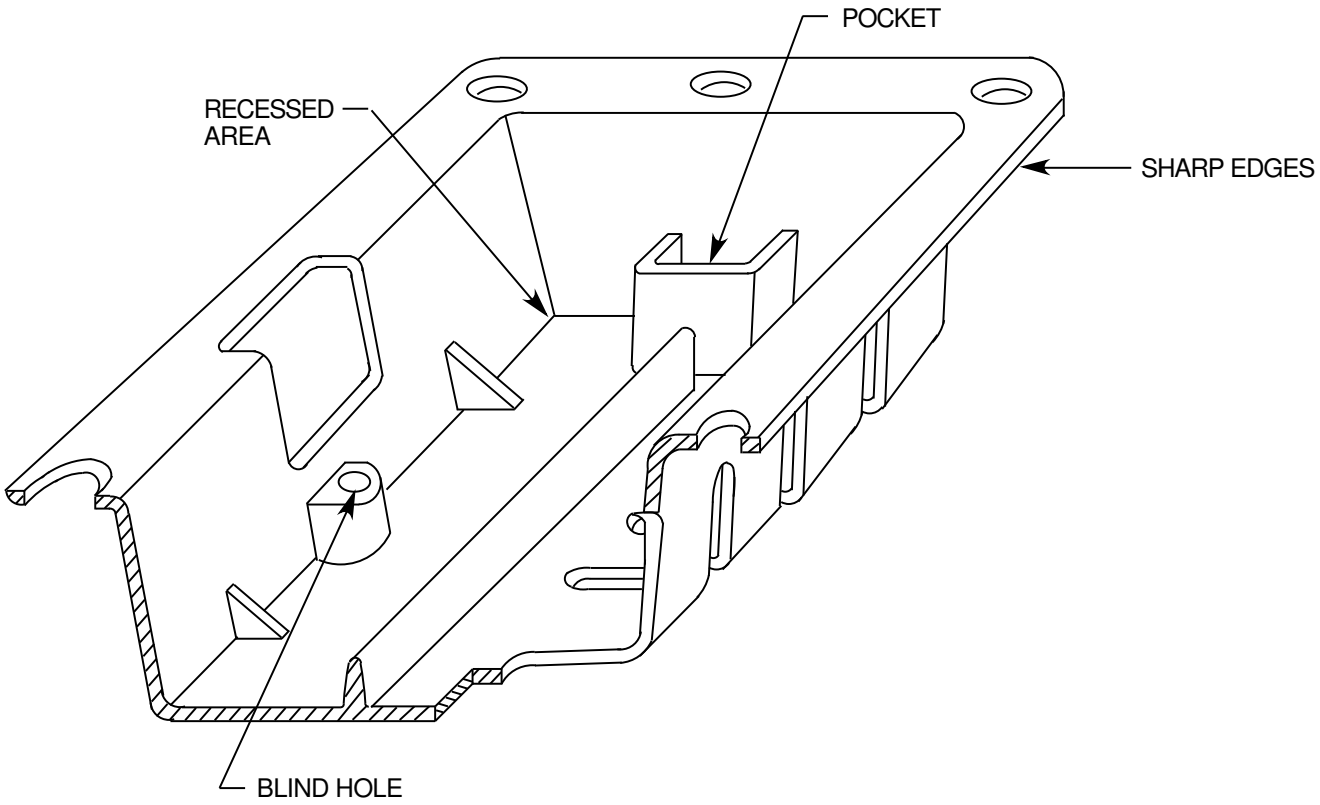


Figure 2–16: Wearability Enamel/Lacquer



2.5.4 PLATE

INFORMATION

RULE/S:

Features within the plating process will be divided into the following categories. The order of recommended use is:

- Copper/nickel/chrome
- Copper/nickel (electroless)
- Copper/nickel (electrolytic)
- Copper/nickel/gold (for special applications only, for instance, circuit boards)

NOTE: Refer to DEC STD 092-0 for more specific information.

REASON/S:

- The relative ranking is based upon technical expertise and available/ approved vendor base.
- These feature categories should support most engineering requirements for finishing (wearability of) plastic substrates and will support future AI tool development, for example, The Design Advisor.

ALTERNATIVE:

Not applicable

ALTERNATIVE IMPACT:

Not applicable

2.5.5 PLATE—ELECTROLESS

INFORMATION

RULE/S:

1. Electroless plating is a finishing process with the following characteristics:
   - Has plastic (substrate) material limitations due to the high temperature associated with the electroless process.
   - Has less abrasion resistance than electrolytic coatings.
   - Generally, a more cost-effective process than electrolytic.
   - Process creates a dull surface finish and is susceptible to surface discoloration (for instance, finger prints).
   - Has paint adhesion capabilities.
   - Has size constraints (for instance, large parts may be difficult to plate).
   - Irregular surface conditions, blind holes, recessed areas, and so on, can lead to processing problems (such as, poor drainage areas).

     NOTE: Refer to DEC STD 092-0 for more specific information.

REASON/S:

- Electroless is a high temperature submersion plating process.
- Electroless plating requires a preconditioned surface for proper adhesion.
- Process requires good part drainage characteristics.
- Electroless is a nonleveling type plating process.
- The process is limited to the physical capabilities of the vendor base (for instance, the plating tank size).
- Low abrasion resistance is due to thickness of plating.

ALTERNATIVE/S:

- Electrolytic plating
- Paint
- Special coatings
- Molded-in characteristics

ALTERNATIVE IMPACT: Positive or negative impact of alternative would have to be evaluated based upon specific design requirements. See a Producibility Engineer.

2.5.6 PLATE—COPPER/NICKEL (ELECTROLESS)

GUIDELINE

RULE/S:

1. Irregular surface conditions, blindholes, recessed areas, and so on, can lead to processing problems (such as, poor drainage areas). See Figure 2–17.
2. Molded-in stress must be avoided.
3. Plastic substrate and electroless nickel process must be compatible. See a Producibility Engineer and DEC STD 092-0 for specific design recommendations.
4. Has good paint adhesion capabilities

REASON/S:

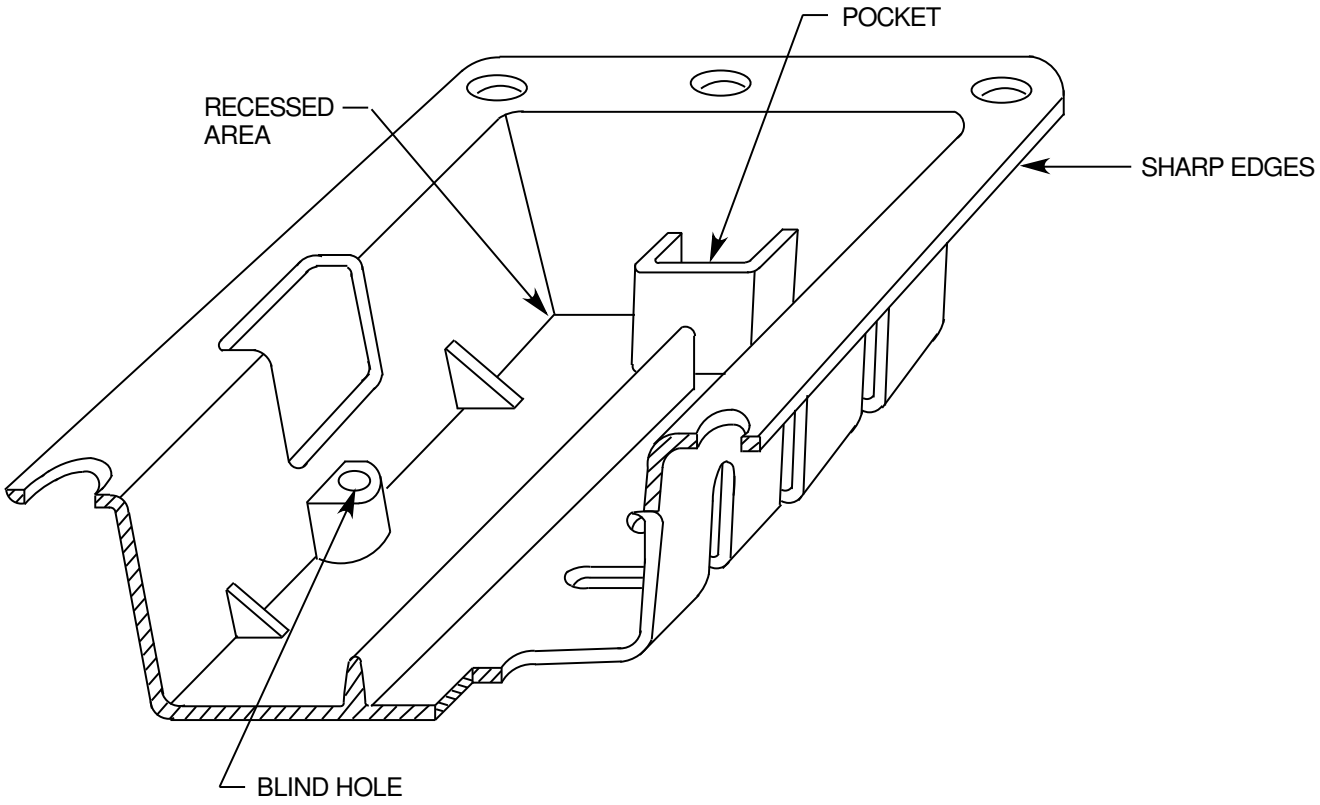
- Irregular surface conditions, blind holes, sharp edges, and so on, can lead to poor adhesion and/or non-uniform plating of plastic substrates.
- Molded-in stress results in improper adhesion of plating.
- Process requires good part drainage.

ALTERNATIVE/S:

- Molded-in compounds in base materials
- Copper/nickel/chrome or copper/nickel (electrolytic) plate
- Paints

ALTERNATIVE IMPACTS: Positive or negative impacts of alternatives would have to be evaluated based upon specific design requirements. See a Producibility Engineer.

Figure 2–17: Plate—Copper/Nickel Wearability (Electroless)



2.5.7 PLATE—ELECTROLYTIC

INFORMATION

RULE/S:

1. Electrolytic plating is a finishing process with the following characteristics:
   - Has plastic (substrate) material limitations due to the high temperature associated with the plating process
   - May require an electroless undercoat for adhesion
   - Has better abrasion resistance than electroless coatings
   - Preferred for thick coating applications
   - May have bright finish capabilities
   - Has poor paint adhesion capabilities
   - Has size constraints (for instance, large parts may be difficult to get plated)
   - Generally less susceptible to surface discoloration (for instance, finger prints) than electroless plating
2. Irregular surface conditions, blind holes, recessed areas, and so on, can lead to processing problems, such as poor drainage.

NOTE: Refer to DEC STD 092-0 for more specific information.

REASON/S:

- Plating is a high temperature, submersion process.
- Electrolytic plating requires a conductive surface for proper adhesion.
- Process requires good part drainage characteristics.
- Process produces a non-uniform buildup of plating material.
- Process is limited to the physical capabilities of the vendor base (for instance, the plating tank size).
- Irregular surface conditions, blind holes, recessed areas, and so on, can result in poor adhesion or non-uniform coating (thickness and coverage).
- Improve abrasion resistance is due to thickness of plating.

ALTERNATIVE/S:

- Molded-in characteristics
- Paint

- Special coatings

ALTERNATIVE IMPACT: Positive or negative impact of alternative would have to be evaluated based upon specific design requirements. See a Producibility Engineer.

2.5.8 PLATE—COPPER/NICKEL/CHROME (ELECTROLYTIC)

GUIDELINE

RULE/S:

1. Irregular surface conditions, blind holes, recessed areas, and so on, can lead to processing problems (such as, poor drainage areas). See Figure 2–18.
2. Molded-in stress must be avoided.
3. Plastic substrate and electrolytic chrome process must be compatible. See a Producibility Engineer and DEC STD 092-0 for specific design recommendations.

REASON/S:

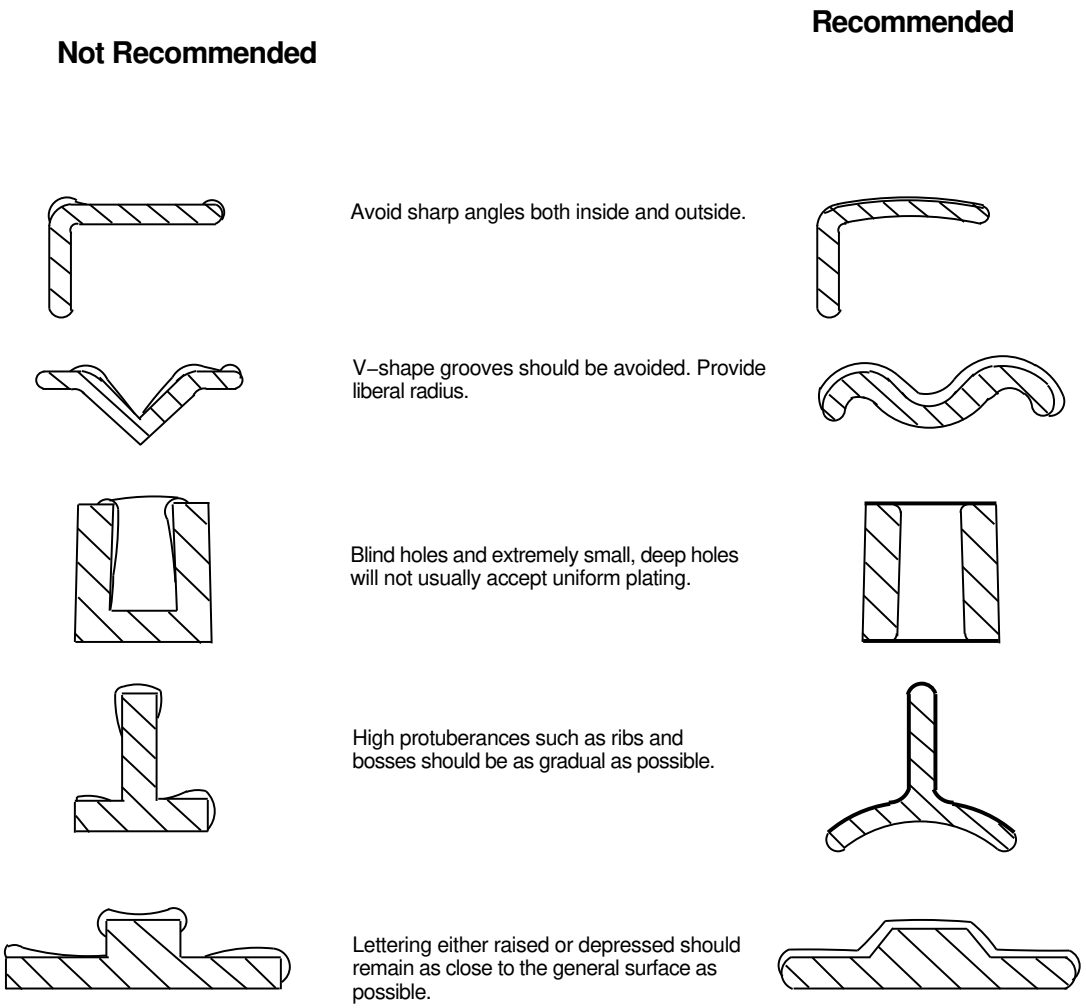
- Irregular surface conditions, sharp edges, blind holes, and so on, can lead to poor adhesion and/or non-uniform plating of plastic substrates.
- Molded-in stress increase the risk of surface cracks leading to improper adhesion of plating and reduced flexibility of base material.
- Chrome has poor paint adhesion capabilities.

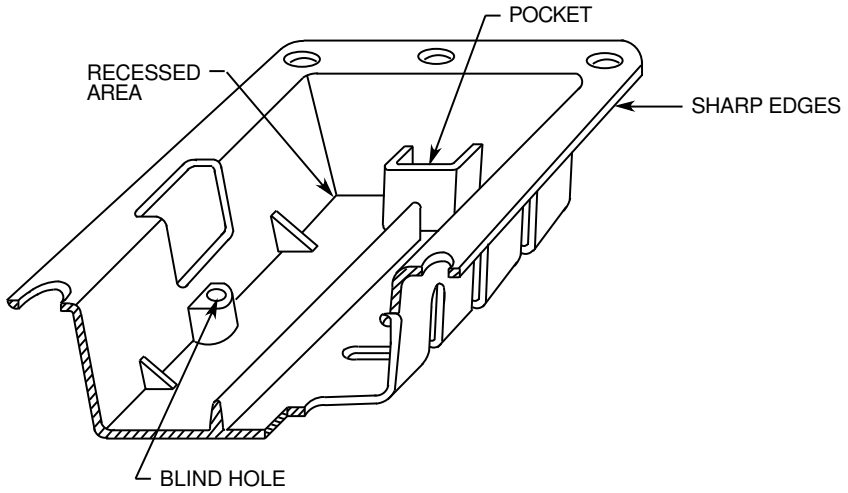
ALTERNATIVE/S:

- Molded-in characteristics in base materials
- Copper/nickel plate
- Paint

ALTERNATIVE IMPACTS: Positive or negative impacts of alternatives would have to be evaluated based upon specific design requirements. See a Producibility Engineer.

Figure 2–18: Plate—Copper/Nickel/Chrome (Electrolytic)


Not Recommended
Recommended
Avoid sharp angles both inside and outside.
V–shape grooves should be avoided. Provide liberal radius.
Blind holes and extremely small, deep holes will not usually accept uniform plating.
High protuberances such as ribs and bosses should be as gradual as possible.
Lettering either raised or depressed should remain as close to the general surface as possible.



2.5.9 PLATE—COPPER/NICKEL (ELECTROLYTIC)

GUIDELINE

RULE/S:

1. Irregular surface conditions, blind holes, recesses areas, and so on, can lead to processing problems (such as, poor drainage areas). See Figure 2–19.
2. Molded-in stress must be avoided.
3. Plastic substrate and electrolytic nickel process must be compatible. See a Producibility Engineer and DEC STD 092-0 for specific design recommendations.
4. Preferred over electroless when wearability and cosmetics are required.
5. Has poor paint adhesion capability.

REASON/S:

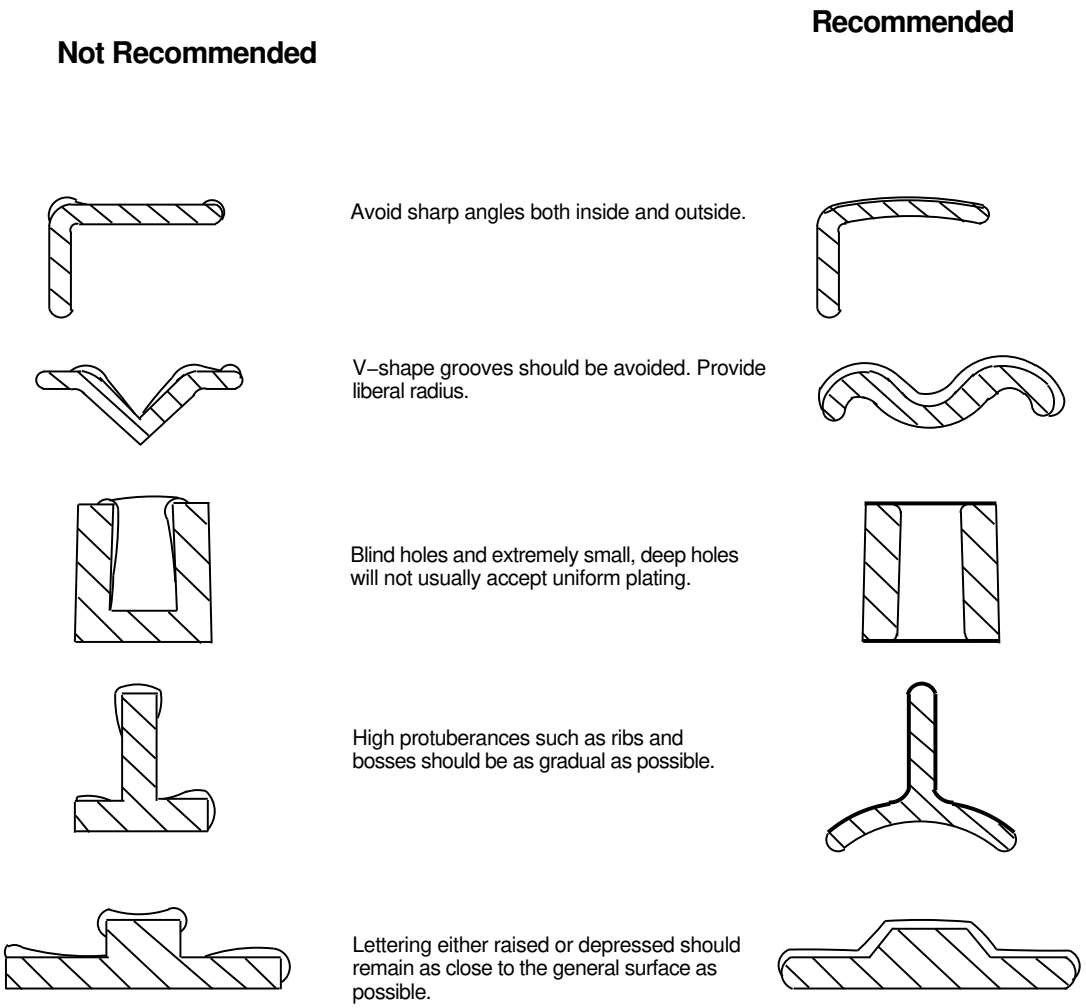
- Irregular surface conditions, sharp edges, blind holes, and so on, can lead to poor adhesion of plating to plastic substrate.
- Molded-in stress results in improper adhesion of plating.
- Process requires good part drainage.

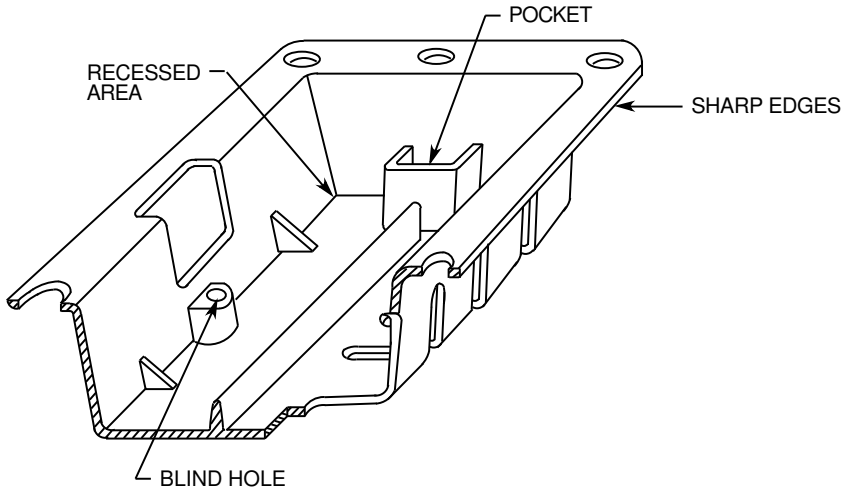
ALTERNATIVE/S:

- Molded-in characteristics in base materials
- Copper/nickel/chrome plate
- Copper/nickel electroless
- Paint

ALTERNATIVE IMPACTS: Positive or negative impacts of alternatives would have to be evaluated based upon specific design requirements. See a Producibility Engineer.

Figure 2–19: Plate—Copper/Nickel (Electrolytic)


Not Recommended
Recommended
Avoid sharp angles both inside and outside.
V–shape grooves should be avoided. Provide liberal radius.
Blind holes and extremely small, deep holes will not usually accept uniform plating.
High protuberances such as ribs and bosses should be as gradual as possible.
Lettering either raised or depressed should remain as close to the general surface as possible.



2.5.10 SPECIAL COATINGS

INFORMATION

RULE/S:

Features within the special coating process will be divided into the following categories:

- Vacuum deposition
- Flame/arc spray (not recommended)
- Topical lubricants (not recommended)

NOTE: Refer to DEC STD 092-0 for more specific information.

REASON/S:

- There are other more cost-effective methods of providing wearability for plastics.
- These feature categories should support most engineering requirements for finishing (wearability of) plastic substrates and will support future AI tool development, for example, The Design Advisor.

ALTERNATIVE/S:

- Molded-in characteristics in base materials
- Paint
- Plating

ALTERNATIVE IMPACT: Positive or negative impacts of alternatives would have to be evaluated based upon specific design requirements. See a Producibility Engineer.

2.5.11 SPECIAL COATINGS—VACUUM DEPOSITION

GUIDELINE

RULE/S:

1. Irregular surface conditions, blind holes, recessed areas, and so on, can lead to processing problems. See Figure 2–20.
2. The process has size limitations. See a Producibility Engineer for design information.

   NOTE: Refer to DEC STD 092-0 for more specific information.

REASON/S:

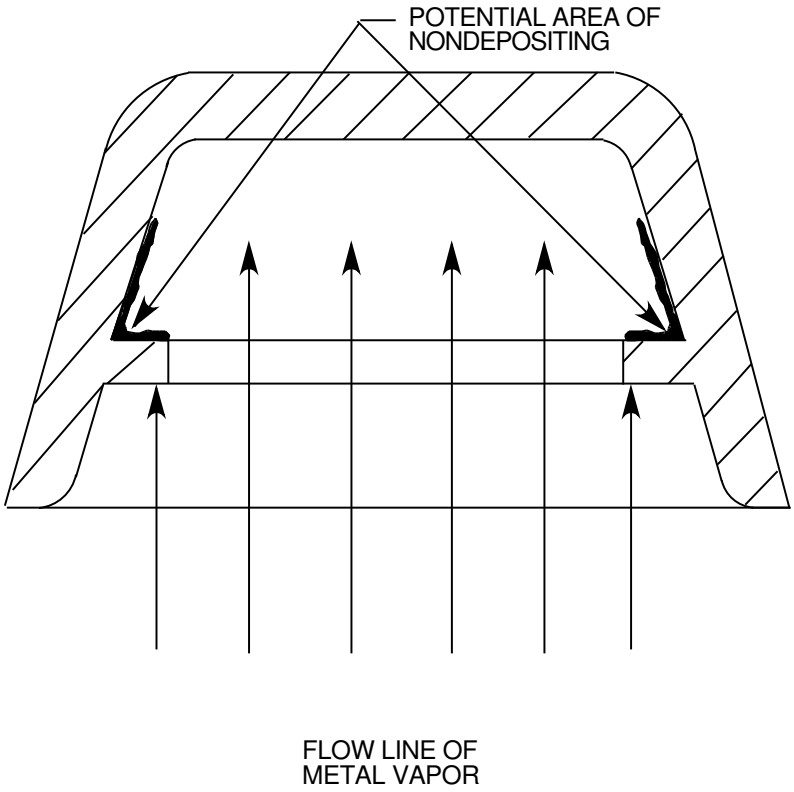
- Vacuum deposition is applied using a vapor process (not spray or immersion).
- The vacuum deposition process requires that all surfaces are accessible to the metal vapor.
- The process is limited to the physical capabilities of the limited vendor base (for instance, vacuum chamber size).
- Irregular surface conditions, blind holes, recessed areas, and so on, can result in poor adhesion or non-uniform coating (thickness and coverage). See Figure 2–20.

ALTERNATIVE/S:

- Molded-in characteristics in base materials
- Plating
- Paint

ALTERNATIVE IMPACT: Positive or negative impacts of alternatives would have to be evaluated based upon specific design requirements. See a Producibility Engineer.

Figure 2–20: Special Coatings—Vacuum Deposition



GLOSSARY

compatible:: Two or more materials that can be used in conjunction with one another, without any detrimental effects on any one material or the result of the combination.

corrode:: To dissolve or wear away gradually, especially by chemical action.

cosmetic:: Pertaining only to appearance qualities.

dissolve:: To cause to pass into solution (liquify).

DEC STD 092-0: *DEC STD 092-0 Finish and Color Standard - Introduction and General Requirements*

electroless:: Deposition of a metallic coating by a controlled chemical process (in a solution), without the use of an electric current.

electrolytic:: Pertaining to the deposition of a metallic coating by electroplating on a substrate immersed in a solution (electrolytic).

EMI:: Electromagnetic interference.

enamel:: A vitrious (glossy), usually opaque, protective or decorative coating baked on metal, glass, or ceramics.

epoxy paint:: Any of various usually thermosetting resins, capable of forming tight cross-linked polymer structures characterized by toughness.

etch:: To cut into the surface of a substrate by the action of acid or alkaline solutions.

flame/arc spray:: A type of thermal spray where the coating metal is melted, atomized, and delivered to the substrate by compressed air or other gasses.

fretting corrosion:: A worn spot made by abrasion or erosion, resulting in a corrosive action.

geometry:: The basic shape of a part, the relationship between surface angles and other aspects.

lacquer:: Any of various clear or colored synthetic coatings made by dissolving cellulose derivatives together with plasticizers and pigments in a mixture of volatile solvents and used to give surfaces a gloss.

leveling:: Surfaces with no significant variations in the form of elevations or depressions.

line-of-sight:: An imaginary line from the eye (source) to the object (substrate) being observed.

metal deposition:: Any process that deposits a thin layer of metal on a substrate.

molding:: A mechanism required to form thermoplastic or thermosetting materials.

paint:: A mixture, usually of a solid pigment in a liquid vehicle, used as a decorative or protective coating.

plate:: Metal deposited on a substrate by electrolytic or electroless process.

powder coat:: Any paint that is applied to a substrate in a dry solid or powder form, then heated above its melting point to produce a paint film.

primer coat:: Pertaining to painting; a coating required to ensure compatibility between the paint and substrate, for instance, adhesion promoting primers.

RFI:: Radio frequency interference.

shielding:: Protection of electronic devices against EMI/RFI emissions.

submersion process:: To place or plunge under water or other liquid.

substrate:: Base material.

texture:: The representation of the structure of a surface as distinct from color or form.

urethane:: Any of various thermoplastic or thermosetting resins, widely varying flexibility, used in tough chemical resistant coatings.

vacuum deposition:: The process of depositing metals by evaporation from a source in a high-vacuum environment onto a substrate, for example, vacuum deposition of aluminum.

water-borne:: A liquid paint using water as the carrier.

wearability:: The ability of a material to withstand damage or degradation through extended use.

APPENDIX A REFERENCED DOCUMENTS

A.1 EL-Class Digital Documents

EL-Class Number	Document Title
EL-00092-00	*DEC STD 092-0 Finish and Color Standard - Introduction and General Requirements*

Use VTX SMC to order copies of EL-class documents from Standards and Methods Control. Send distribution questions to JOKUR::SMC or call DTN: 234-4423.

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